GEOPHYSICAL METHODS:

A CASE STUDY AT THE PATTY ANN FARMS SITE 12H1169

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ABSTRACT

THESIS: GEOPHYSICAL METHODS AND SPATIAL ANALYSIS:

A CASE STUDY AT THE PATTY ANN FARMS SITE 12H1169

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The goal of this thesis research is to examine the Patty Ann Farms site using noninvasive techniques, such as a magnetic gradiometer. The Patty Ann Farms site, 12H1169, located in northeastern Hamilton County Indiana, is a multicomponent archaeological site spanning all periods of prehistory. Diagnostic artifacts from the Paleo-Indian, Archaic, and Woodland periods have been surface collected by the land owner. The land owner's collection was documented, and the site was recorded at the Division of Historic Preservation and Archaeology--Department of Natural Resources, in 2004. Since then, a controlled surface survey has been conducted identifying three areas of high artifact density and preliminary soil phosphate tests have been conducted.

Acknowledgements

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Chapter 1

Introduction

The goal of this thesis is to evaluate the effectiveness of noninvasive geophysical techniques using the Patty Ann Farms (PAF) site as a case study. The techniques include controlled surface survey, magnetic gradiometer, soil phosphate testing, and include the evaluation of the results of these methods through comparisons of the collected data. The information derived from the data will support the advocacy of noninvasive testing as an alternative to excavation. Archaeological sites are non-renewable resources. After a site is excavated the *in situ* information, garnered from the process of excavation no longer exists. Exhausting all noninvasive techniques without utilizing excavation preserves the integrity of the site for future generations. The enlistment of support, for archaeological projects, from the community including descendants, property owners, and other interested parties is facilitated by the perceived respect shown to the site through the use of noninvasive techniques. The purpose of this research is to evaluate the utility of each of the three noninvasive techniques employed at this site. By comparing the results of each of these methods, with their limitations, the results will be valuable for ascertaining the utility of use of the methods in relationship to similar sites. Each method has limitations based on the environment, soil characteristics, topography, and the operator or surveyor. Understanding the differences in the limitations will help future researchers decide which methods are best to combine.

It is the goal of this thesis to provide accurate and comprehensive information on the methods of geophysical archaeology using the study site, as the case study. This thesis contributes to the current state of knowledge for the archaeology of Hamilton County, Indiana, and provides information relative to cultural resource management for data storage and analysis. This thesis attempts to provide a thorough and useful literature review for several methods including controlled surface surveys, memory surveys, subsurface soil phosphate testing, and magnetometry in addition to case studies employing these methods. Additionally, this thesis contributes to Indiana archaeology and to Midwest archaeology in general.

The study site, 12H1169, is located in northeastern Hamilton County, Indiana, (Figures 1 and 2) and is a multicomponent site spanning all periods of archaeological prehistory. Prior to documentation, diagnostic artifacts from the Paleo-Indian, Archaic, and Woodland periods were surface collected by the land owner. The land owner's collection was documented (Appendix A), which led to the recording of the site with the Division of Historic Preservation and Archaeology-Department of Natural Resources, in 2004 by Jennifer Wyatt (Wyatt 2005).

The site was selected largely because of the relationship between the land owner and the author of this thesis. Miles Wyatt is Jennifer Wyatt's father and because of this relationship some of the formal consent that is usually acquired for access to a site was

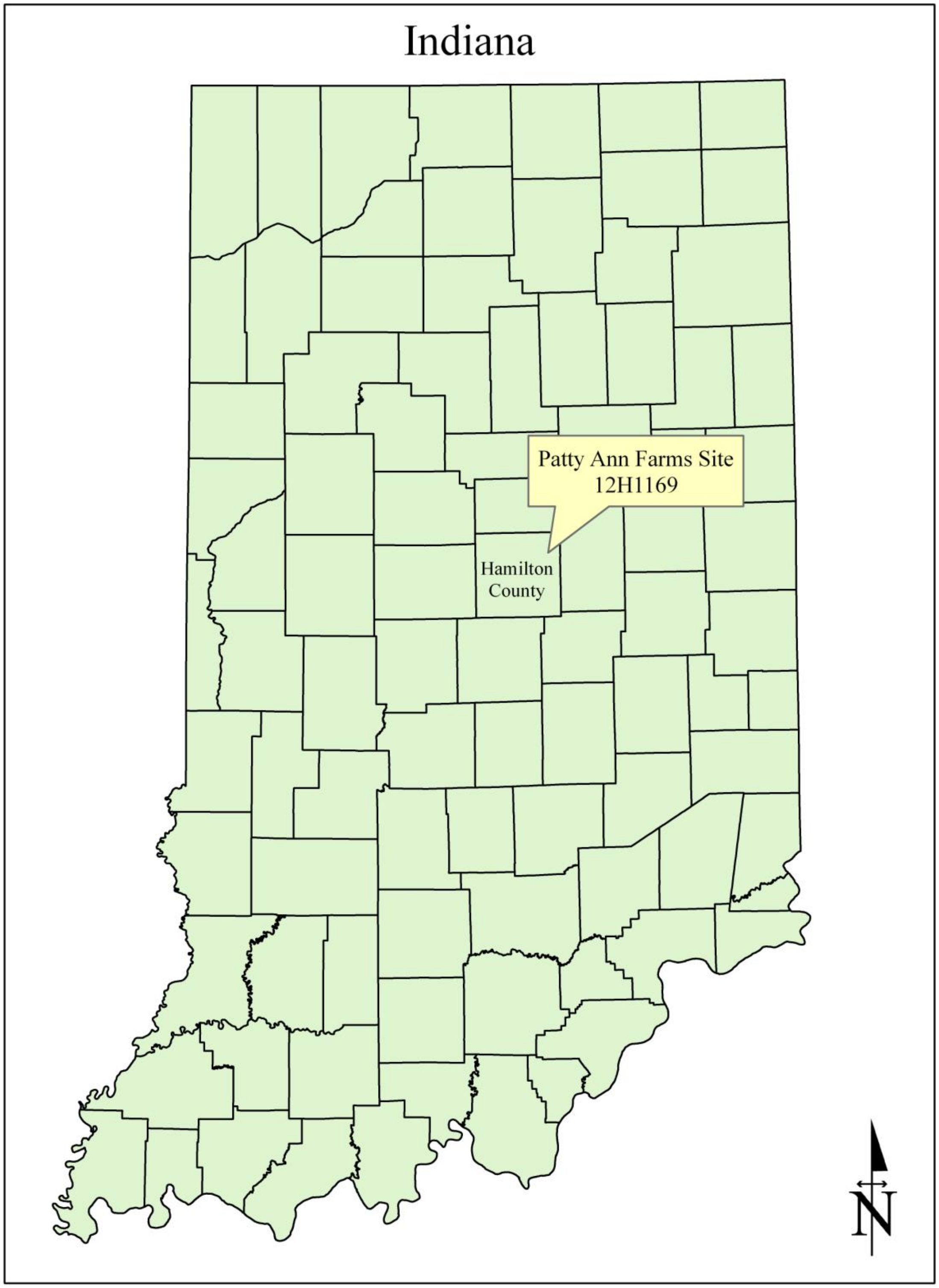

Figure 1. Map showing the location of the Patty Ann Farms site within the state of Indiana.

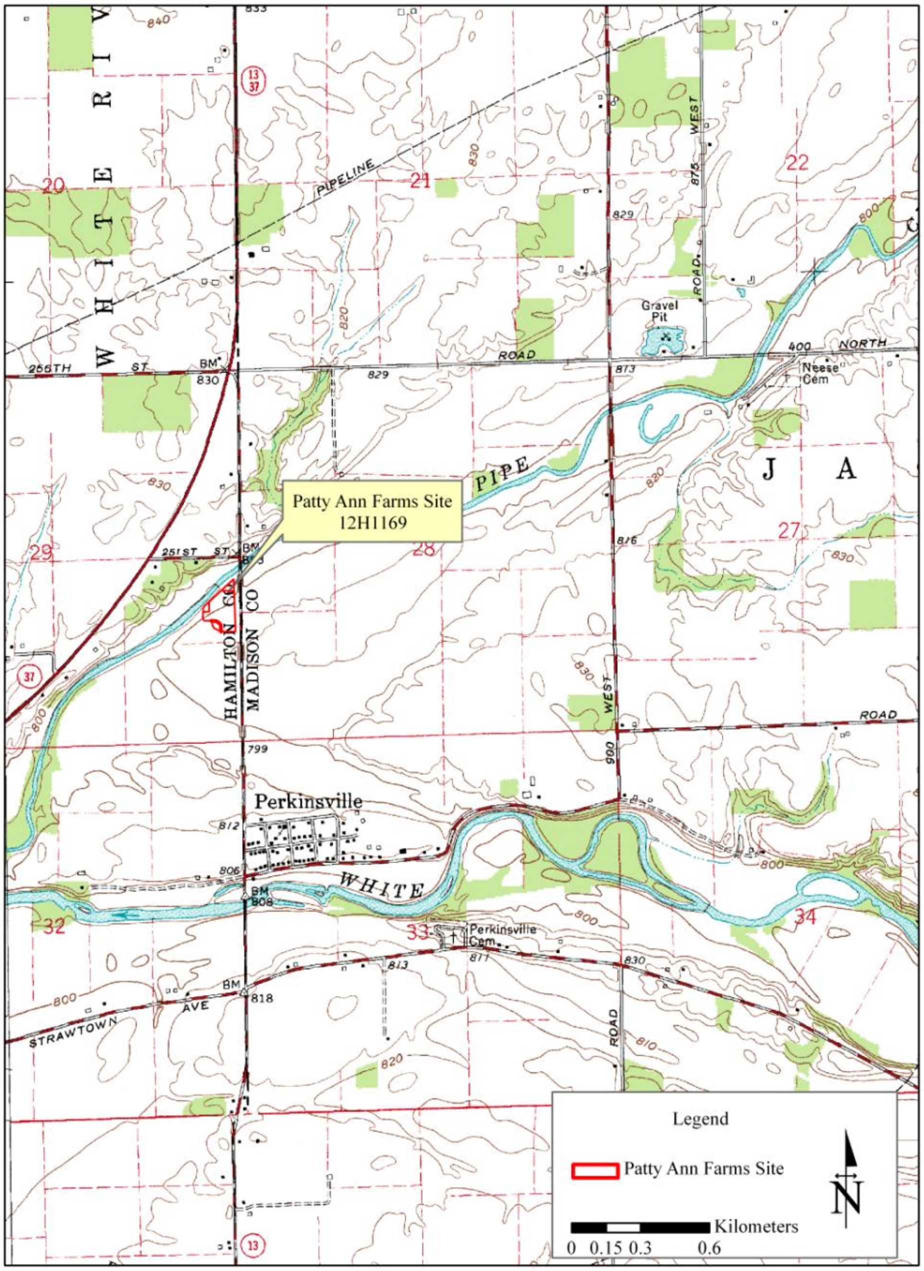

Figure 2. Portion of a USGS 7.5' series Frankton and Omega quadrangles (USGS 1962) showing the Patty Ann Farms site 12H1169.

overlooked. The land owner was very active in all aspects of the field research at this site. The landowner is particularly concerned with trying to maintain a level of stewardship with respect to what is beneath the ground.

Mr. Wyatt is concerned with preserving the site, developing as much site information as possible, and with contributing to the current state of knowledge in Indiana archaeology. Mr. Wyatt is also concerned as a descendant of the Choctaw Nation. All persons who have any kind of stake in artifacts should be concerned with the stewardship of the site. Land owners, collectors, archaeologists, Native Americans, researchers, and even community members all play an important part in the list of people who have special interests in the site. Because this list is so long, and because of the potential for the site to be significant, it is extremely important to disrupt the site as little as possible during the research and preservation of the site.

Therefore it is hypothesized that, by using the data from a controlled surface survey, soil phosphate tests, and magnetometer survey, a more refined image of the subsurface features will be created for the archaeologist or researcher prior to more invasive site testing. The evaluation of these methods will show the limitations, as well as the strengths for this case study and similar sites. By using noninvasive techniques the researcher, who is responsible for the stewardship and integrity of the site during the research, can evaluate the methods used to be able to make more informed decisions about where to place excavation units, thus preserving as much of the site for future generations as possible.

During 2005, after the site was recorded, surface surveys were formulated. The controlled surface survey was conducted during the spring of 2006 to delineate areas of high artifact density (HAD) (Wyatt 2006). The 1.82 hectares (4.5 acres) field was divided into approximately 55 transects spaced 4.572 meters (15 feet) apart and were surveyed by walking from east to west. The collected artifacts were plotted on maps that were carried by the surveyors. The field maps were then used to create spatial distribution maps of the collected lithic artifacts using the *Surfer 8* computer mapping program. It was discovered that the 1.82 hectares (4.5 acres) contained three high artifact density (HAD) areas (Figure 3). The pedestrian survey is discussed in detail in a later chapter. The three HAD areas were where all subsequent testing was conducted. Since the time of the controlled surface survey, the three areas were taken out of cultivation to preserve the integrity of the subsurface features as well as to expedite further investigation.

In the spring of 2007, initial soil phosphate tests were conducted in the three HAD areas and in one random sample area to determine if phosphate testing was an applicable method for thesis research (Wyatt 2007). The initial tests indicated no contamination with fertilizer derived phosphates below the plow zone. The plow zone is considered to be from the ground surface and extending downward to a depth of 30 centimeters (11.8 inches). The results of the initial phosphate test in the HAD areas demonstrated the presence of non-fertilizer phosphates, which was encouraging.

The presence of non-fertilizer phosphates below the plow zone justifies the next level of testing involving a coarse sampling interval of soil phosphate tests. In the late summer of 2007, soil samples were collected from all three HAD areas in a grid pattern of 9.144 meters (30 feet). These soil samples were tested for organic phosphates. The

Figure 3. Portion of a 2006 color aerial map showing the Patty Ann Farms site and the high artifact density areas.

data from this survey was also entered into the *Surfer 8* computer mapping program to generate a spatial distribution map. The resulting map denoted the results of the phosphate tests which facilitated easier visualization of the areas with high phosphate concentrations. The areas of high phosphate levels agreed with the areas of high artifact density. Further discussion of the soil tests and results are discussed in Chapter 5.

The last component of this noninvasive multi-method investigation was the magnetometer survey. The magnetometer survey was conducted in September of 2008 using a FM 36 Fluxgate Magnetometer on loan from the Applied Archaeologies Laboratories, Department of Anthropology, Ball State University. The survey was conducted using the same grid as all previous surveys. However, for the purposes of the software matching, the survey was completed in 20 by 20 meter blocks utilizing a one meter interval between traverses, and manually logging readings every half meter along the traverse. The results of this survey were then uploaded to a computer utilizing *Geoplot 3.0*. The presence of a few small anomalies is discussed in more detail in Chapter 5.

The most encouraging results come from the controlled surface survey, however the soil phosphate survey results, and the magnetometer survey results were not unproductive. The use of multiple noninvasive survey methods only reinforces the horizontal distribution limits of subsurface remains.

Chapter 2

Site Background

The purpose of this chapter is to discuss the cultural and physical environment in which the study site is located. The site setting is important to researchers because it allows the context of the site to be evaluated in addition to the site itself. The cultural history in this chapter is written in a standard format that archaeologists in the state of Indiana will recognize, beginning with the historical cultural context and then the prehistoric cultural context. In conducting research concerning cultural land use it is important to consider all the people that have an interest in the study area. Noninvasive methods of study are best suited for projects where there are multiple stake holders in the integrity of the land.

Archaeological background of Hamilton and Madison Counties

The study site is located east of Strawtown, in an area where historic and prehistoric activity is already widely known, and west of Anderson, Indiana (Harden 1874, Helm 1880) (Figure 4). The Conner Trail, a major transportation route for the early settlers of Indiana (Helm 1880), follows the White River and is about one mile south of the study site. While the study site is located on Pipe Creek, it is roughly one mile north of the White River. Many of the sites that are nearest the study site are located along the White River. Historically this area was a trading route first for Native Americans and then for fur traders and settlers as the western world encroached on the region (Helm 1880). Several historic Delaware villages were located along this portion of the White River, including Strawtown, Taylor Village, Nancy Town, Anderson's Town, and Sarah Town (Helm 1880). Kikthawenund, a historic Delaware village, is located about four kilometers (2.5 miles) upstream from the study site. In addition, one source gives the location of another trading post about 6.4 kilometers (four miles) upriver from Strawtown, which is located at the confluence of Pipe Creek and White River which is one mile downstream from the study site (Harden 1874; Helm 1880).

The prehistoric culture context of Hamilton County and East Central, Indiana, is represented by all periods of Indiana Prehistory. This general cultural sequence, from Paleo-Indian through Euro American contact, is relatively well documented and has been outlined in a number of widely available sources (e.g., Cochran 2004; Hicks 1992; Jones and Johnson 2003; Kellar 1983; Stafford 1997; Swartz 1981). The study site has yielded artifacts, such as Paleo-Indian points, from surface collecting episodes that enable the site to be potentially eligible for a listing on the National Register of Historic Places.

The Paleo-Indian component of the study site is represented by six diagnostic points, including Agate Basin, late Paleo-Indian, late Paleo-Indian Lancelet, Dalton Cluster, and two Dalton point fragments (see Appendix A).

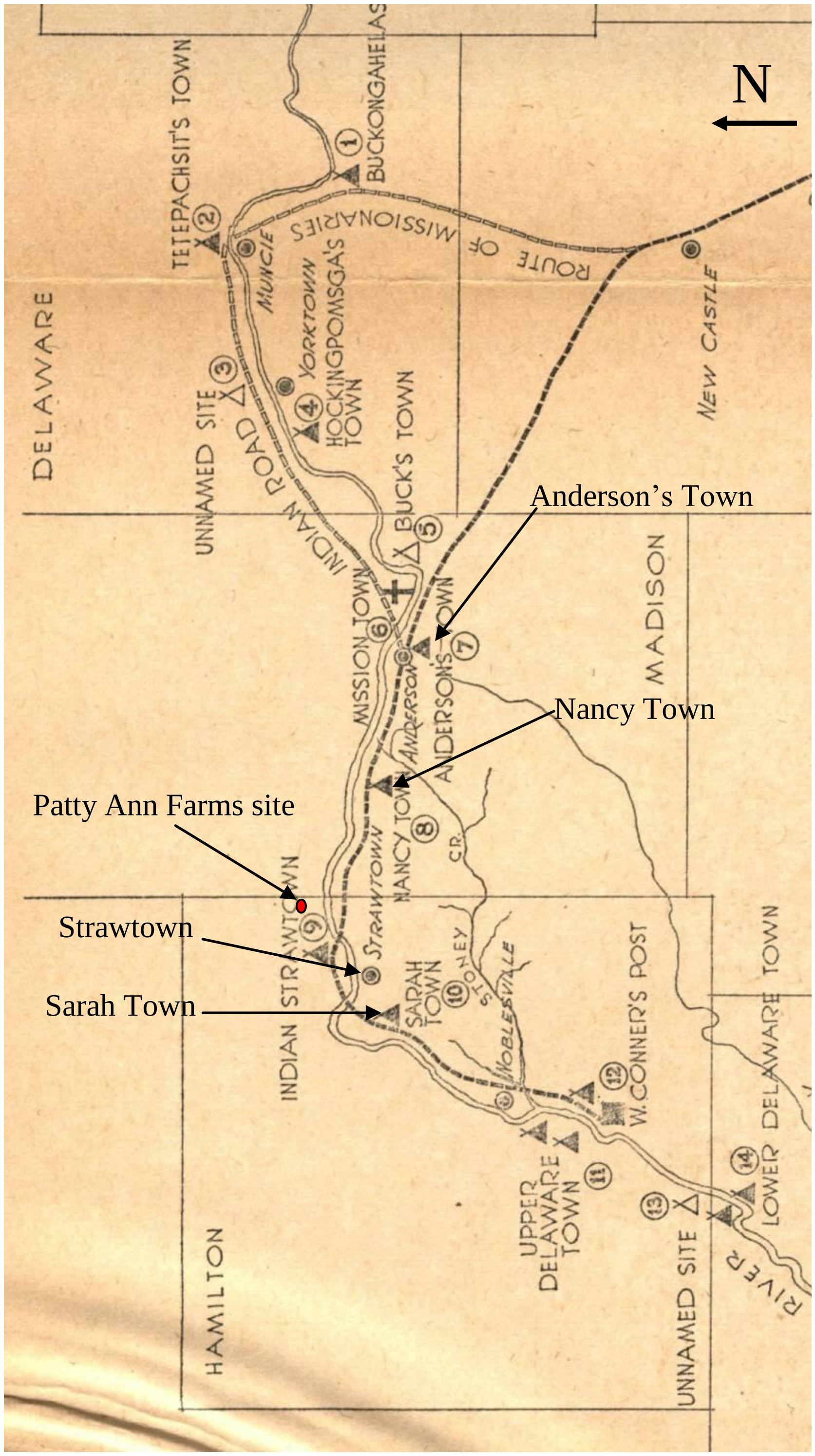

Figure 4. Portion from a map showing several Native American Villages (Thompson 1937:48), the study site has been added to show proximity to the villages.

As of 1990, only 11 documented Paleo-Indian points were from Hamilton County (Tankersly *et al.* 1990).

The points from the study site bring the 1990 total to 17, and representing 35.3 percent of the total Paleo-Indian points for the county. This is significant because the total number of documented Paleo-Indian points for Indiana, at the time of the 1990 Tankersly *et al.* paper, was 583. The total would increase to at least to 589 with the addition of the study site points. This is equivalent to one percent of the total number documented in Indiana (Tankersly *et al.* 1990). The study site could become one of a very few sites in Indiana to have stratified subsurface Paleo-Indian deposits, which could greatly aid in the current state of knowledge of Paleo-Indian life in Indiana because there are no excavated and recorded stratified Paleo-Indian sites from this portion of the state.

The Archaic period for the region of the state is represented by the Glacial Kame culture. The Woodland period is represented by Adena (Kellar 1960), Albee (McCord 2005), and Oliver (White *et al.* 2002). The Adena phase is represented by the C.L. Lewis Mound, and Mounds State Park (Kellar 1960). The Albee Phase is represented by the Hesher site, Van Nuys site, Commissary site, and the Morrell-Sheets site (McCord 2005). The Oliver Phase is represented at the Strawtown Enclosure (White *et al.* 2002).

The Mississippian is represented in the region by the Oliver Phase as it continues from the Late Woodland period. The Bowen site as recorded by Dorwin (1971) is a good example of Oliver Phase. The study site has not yielded any Mississippian artifacts even though it is approximately eight kilometers (five miles) upstream from the Oliver Phase site in Strawtown.

Archaeology in Hamilton County has been conducted over a large portion of the county because of rapid urban expansion and development of farm lands. The portion of the county that lies in the Frankton Quadrangle, east of the Omega Quadrangle, has five sites that are recognized by the Indiana Division of Historic Preservation and Archaeology; this includes the study site (12H1169). The study site encompasses a four-acre area within a cultivated field. The planting alternates annually between soybeans and corn. Originally, the entire 14-acre field was cultivated, but now a private residence occupies 10 of the acres with the remaining four under cultivation except for the high artifact density areas. The collection used for documenting the site is from the study field shown in Appendix A.

Natural setting

The study site is located in the New Castle Till Plain according to Gray (2000). However, according to Homoya *et al.* (1985), the site is located in the Central Till Plain Natural Region of the Tipton Till Plain. Schneider (1966) places the project area within the Tipton Till Plain Region which is characterized by a nearly flat to gently rolling glacial plain interrupted by low eskers, esker troughs, and melt water drainage ways. Surface deposits from the Wisconsin Glaciation account for much of the glacial till covering the underlying Silurian bedrock (Gutschick 1966, Wayne 1966). Gravel cherts found along major drainages and geologic features of glacial till and outwash are a major source of chert for this region, however an outcrop of Fall Creek Chert is located in southeastern Hamilton County (Cantin 2005). The pre-settlement vegetation of the region consisted of Beech-Maple forest types (Petty and Jackson 1966) and included natural communities of minor areas of bog, prairie, marsh, seep spring and pond communities (Homoya *et al.* 1983). The project area is within the West Fork of the White River Basin. According to the Hamilton County Geographic Information System (1997) and illustrated in Table 1, the soils present on the surface of the study site include Fox loam; Shoals silt Loam, and Sleeth loam (Figure 5).

Chapter summary

The cultural context and natural setting are important to consider when designing a research plan for an archaeological site. Awareness of the surrounding documented sites is crucial as far as placing the site in context with the rest of the region. In addition thorough background research will allow the researcher to evaluate the significance of the site in relationship to the definition of significance given for the National Register of Historic Places. Based on the information presented in this background discussion, the study site has the potential to be significant if it contains stratified Paleo-Indian deposits which are missing from this portion of the state. The information from the natural setting discussion in this chapter can help educate the researcher as far as possible limitations of the research design. The biggest limitation of the research design for this site is the majority of the field is still under cultivation. While the second major limitation is that HAD2 is located within the area that floods annually. However, the areas that are not flooded annually and the areas that are out of cultivation are suitable for all forms of investigation proposed in the research design of this thesis.

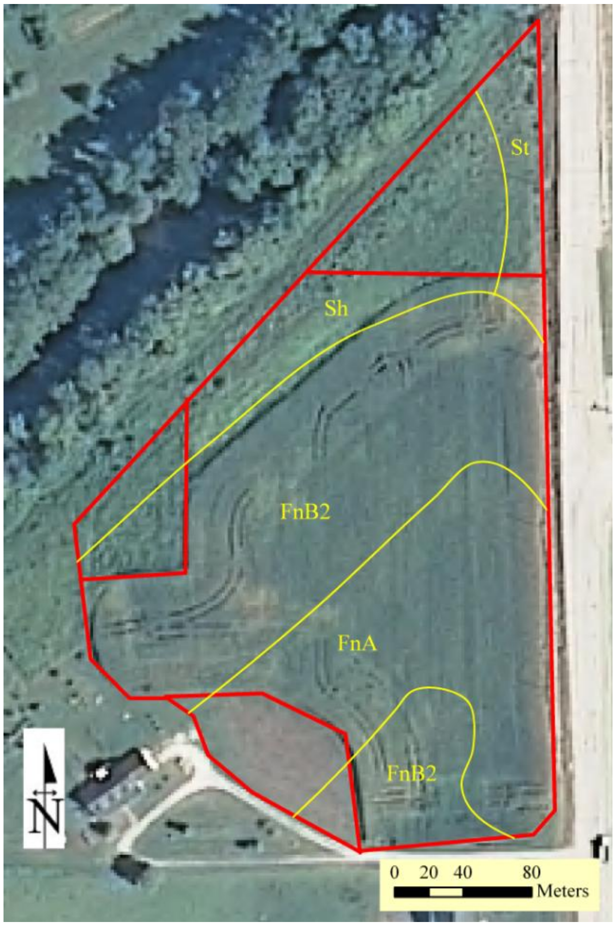

Figure 5. Portion of a 2006 color aerial photograph of the Patty Ann Farms site showing soils.

Table 1. Soil information key for Patty Ann Farms Site.

Symbol	Soil	Description
FnA	Fox Loam 0-2% slopes	Well drained
FnB2	Fox Loam 2-6% slopes, eroded	Well drained
St	Sleeth Loam	Somewhat poorly drained
Sh	Shoals Silt Loam	Somewhat poorly drained

Chapter 3

Literature Review

The purpose of this chapter is to acquaint the reader with several examples of literature regarding various techniques used in this project. The goal of the thesis is to use multiple noninvasive techniques to preserve the integrity of the site while still investigating the subsurface cultural resources. By evaluating current examples of literature that detail each of the methods used, the researcher will be better able to understand the cooperation of using multiple methods.

Several different methods will be discussed in this literature review, including controlled surface surveys and sampling in archaeological survey, on site methods for soil phosphate testing, and remote sensing within the archaeological context. For each of the topics, literature was available from very early in the development history of each technique. However, efforts were made to review current germane articles and texts for the purposes of this review. The major reason for limiting the review to the most current sources is that the methods of conducting these different forms of survey are evolving quickly, as are the ways in which archaeologists interpret the output data. This progression is reflected in the literature review.

Controlled surface survey

Archaeological field information in this study has been gathered through sampling. Archaeological sampling refers to the sample size of the study area; it can also refer to the sample size of the survey, or the sample size of the collection. Most archaeology projects begin with a survey. Surveys generally consist of archaeologists walking over a surface at set intervals and observing the surface of the ground for cultural remains or conducting shovel tests, if the view of the ground is obstructed. Controlled surface surveys can be done in areas with relatively good ground visibility, and can be used to determine where areas of high artifact concentration are located (Redman 1987). A drawback of using controlled surface survey in the research design, according to Redman, is that the method is not always employed or and when it is used, it is not always preformed or analyzed correctly (Redman 1987).

However, the study of the PAF site began with the land owner's collection of points from his own surface collecting episodes. He provided 52 points for the use in this study, as well as indicating his most productive places to look when surface collecting. Because of this information it was possible to formulate a strategy based on a controlled surface survey and to record the results of a formal survey as discussed in Chapter 4.

Archaeological surface deposits, the data that are recorded during a surface survey, are generally regarded as surface reflections of the subsurface archaeological record, and used to delimit preliminary definitions of the area surveyed (Wandsnider and Camilli 1992). "Attributes of archaeological deposits that influence how that deposit is documented include, among other things, the obtrusiveness of artifacts, their clustering, and their density” (Wandsnider and Camilli 1992:171). Wandsnider and Camilli also discuss the seeding experiment, where objects are introduced into an area and then a survey team attempts to collect and record the number of collected objects compared to the number of objects not collected (1992). Experiments like this are important because they demonstrate to the archaeologist the effects of annual tillage, or the effects of natural seasonal processes on the artifact distribution (Wandsnider and Camilli 1992). However the limitation of the method is always temporal. It would be impossible to apply time constraints on the objects introduced in order to replicate all archaeological processes. The goal of this type of study is to understand how to maximize the effectiveness and increase the accuracy of surface surveys (Wandsnider and Camilli 1992).

The artifacts that were present during the controlled surface survey were recorded on maps. The maps were drawn to scale on a grid so that the researcher could then count the total number of each type of artifact present in the controlled surface survey. These maps were used to delineate the extent of the surface deposits within the survey area, as well as to define the density of the artifacts found.

Quantifying surface surveys is popular in archaeological research. Most articles try to estimate the percentage of land surveyed by the size of the transects that are employed for the project, however Sundstrom suggests that a 100 percent survey is a myth; “[t]he number of artifacts located was directly related to the width of the transects, as well as to the more elusive factor of time spent on each transect” (Sundstrom 1993:92). Artifact location is also affected by surface moisture, ambient light, experience of the surveyors, and by the fatigue level of the surveyors. A mathematical formula is suggested in this article to evaluate the adequacy of the interval between transects as compared to the probability of discovering artifacts (Sundstrom 1993). By using this probability formula, the archaeologists should then, given ideal circumstances, be able to increase the reliability of their survey while minimizing variability (Sundstrom 1993). Another way to help eliminate the variability caused by site sampling is to increase the frequency of transects or to conduct a crawling survey (Burger *et al.* 2002-2004). Ultimately the crawling survey is always the most reliable because the sampling is very close to 100 percent. The survey crew would literally crawl over a pre-plotted area that would usually make up one square of a larger grid, after all the grid squares are surveyed, a very precise artifact density is then defined. An attempt was made to use an adapted form of a planned survey in order to accurately estimate the density of artifacts for a large scale survey; however the authors deemed that it was equally efficient to conduct a pedestrian survey (Burger *et al.* 2002-2004).

To control the variability in the survey at the study site, the grid was not only visible on the maps carried by the surveyors, but the grid was also visible on the field. The surveyors were guided by pin flags that represented real points on the map. This enabled the surveyors to plot with reasonable accuracy, the location of the artifacts present.

The idea for the memory survey was inspired by a conversation with Don Cochran, and from an ethnohistory class with Dr. Colleen Boyd. It was suggested by Mr. Cochran that collectors used points as mnemonic devices and that the collectors were able to recall precisely where they found each of their “treasures” based on different memories from the same time. The ethnohistory class placed specific importance on the reliability of individuals to be able to accurately tell their own story. By combining these two ideas, the memory survey was born. The major drawback of this method is that it relies on memory, something the scientific world tends to view as fallible. The memory of any individual is influenced by personal biases. The individual may not think that the object that they found is very interesting or valuable and then choose not to remember where it was found or other factors may influence the individual to remember exactly where the item was found. Encouraging individuals to take notes before and after collecting, or when listening to a story told by an elder, will allow for more areas to be recorded and protected. By integrating the land owner or collector into the survey process it is possible to locate survey areas that are potentially significant. These individuals possess information that is just as valuable as the information from the researcher. Likewise it is important to consider descendant communities and to incorporate their invaluable information (Colwell-Chanthaphonh and Ferguson 2008). Descendants, landowners, and collector informants are crucial to the protection and stewardship of sites because of their continuous presence on or near the sites. Collectors are often reluctant to share where their artifacts are found. Enlistment of collector assistance creates a way for the collector to be acknowledged for their "finds" and encourages more sites to be recorded and in turn protected.

Soil phosphate testing

The first investigation technique to be employed after the initial survey at the study site was the soil phosphate survey. This method is relatively noninvasive and was selected partially for its low site impact. Bioturbation or the mixing of soils by the natural environment, animals, plant roots, and insects, is more invasive than the soil sample required for the phosphate test.

Soil phosphate testing tells archaeologists something about the probability and extent of human habitation (Eidt 1977). Phosphates are found in human wastes; however modern farmers also use phosphates in fertilizers, which could cause conflicting false positives (Eidt 1973). According to Eidt (1973:209), "fertilizer applications in farm fields may cause some interpretive interference…," meaning that the presence of fertilizers could possibly skew the results of the phosphate test. Most archaeological sites, at least in Indiana, are found in cultivated fields. This is true for two reasons, first most of Indiana is, or was cultivated for commercial agriculture in the last 200 years, and second it is easier to find surface artifacts in a cultivated area. However this lends to the problem of false positives in the phosphate testing (White 1978). Because of the likelihood of phosphate fertilizers being used, and the equal likelihood that an archaeological site is located within a cultivated landscape, it is important to note that while this type of testing is useful, it would be more useful in an area where phosphate fertilizers are not used, or in an area that has not been cultivated recently.

According to Eidt (1973) it is suggested that the soil samples be taken from more than 30 centimeters below the ground surface. This distance is commonly referred to as the plow zone. By taking the samples from below the plow zone it creates more of a controlled sample.

> It is worth noting that the aluminum, iron, and calcium retaining components usually found in soils hold phosphate so strongly that fertilizer derived phosphate

> even of the water soluble type may not be expected to move downward more than a few inches from the level of application, i.e., well within the plow zone (Edit 1973: 209).

Edit (1973) also notes in his outline for a qualitative field test, that even in his simple method it is possible to tell the difference between fertilizer derived phosphates and human phosphates because of the difference in the appearance of the blue stain reaction with the special filter paper. Edit's 1973 method is intended to be used during a field survey with soil tests conducted at regular intervals across the field. However Edit (1977) and Woods (1977) provide discussions on more quantitative methods used for soil phosphate testing.

Phosphates are just one of the many chemicals present in soils that are impacted by human land use. According to Leonardi *et al.* the main chemicals that will be present as a result of human activity dating before the Industrial Revolution include not only phosphorus, but also nitrogen, potassium, calcium, magnesium, and sulphur (1999). Testing for phosphates is therefore a useful analysis when exploring possible human activity sites. Phosphorous has a very low "loss factor (Leonardi *et al.* 1999: 346)" *in situ*, meaning that once it is present it is bonded tightly to the original deposition site with very negligible horizontal or vertical movement and no gaseous escape (Leonardi *et al.* 1999). In addition, inorganic phosphorus is "fixed" in the soil solution, insoluble and unavailable to plants; only minimally does it enter into the available soil solution (Leonardi *et al.* 1999: 347). Agriculture actually results in the depletion of soil phosphorus at the level of the plant roots, because "the losses due to plant removal are not replaced by the decomposition of their dead tissues on the soil's surface" (Leonardi *et* *al.* 1999: 347). The remainder of this article examined the utility of several different quantitative soil phosphorus tests. In the event of a more extensive soil survey these would be very useful methods.

Recent articles discuss the implications of using in-field methods such as Eidt's adaptation (1973), and other similar methods (Crowther 1997, Parnell *et al.* 2001, Persson 1997, Rypkema *et al.* 2007; Taylor 2000). Several different in-field methods exist that are comparable to Eidt (1973), however "[t]he choice of method should be governed by the soil type, particularly its pH and metal content" (Rypkema *et al.* 2007: 1862). The soil itself has inherent properties that can affect the results of the type of extracting agent used to separate the phosphates from the soil. According to Rypkema *et al.* (2007), the method need only be reproducible to be viable for analysis. The method that is employed by Rypkema *et al.* (2007) is more costly because of the type of equipment used in the field, such as a pocket computer, and a spectrometer. It is just as easy to take the samples using an Oakfield type soil sampler and to visually gauge the intensity of the phosphate reaction with the reagents and filter paper and to measure the reaction using a ruler and stop watch (Wyatt 2007). This method is far more cost effective for small scale projects.

Geophysical survey

Geophysical survey is also useful for evaluating data about sites; this method involves using different technologies that allow the archaeologist to "see" or to remotely sense what is below the ground without expensive and destructive excavation. Various forms of remote sensing have been in use since the balloonist Tournachon took aerial photographs of Paris from his balloon in 1858 (Brilis *et al.* 2000). The usage of geophysical methods for archaeology began around the late 1940s, and the use of magnetic methods has been applied since around the 1980's (Drahor *et al.* 2008).

This discussion will, however, center on the use of magnetometers for geophysical survey. Magnetometers or fluxgate gradiometers "record the strength of the earth's magnetic field at a point, giving a measurement…[t]his reflects both natural magnetic effects and those produced locally by human behavior" (Clay 2001: 2). This technique is useful because it senses the presence of magnetic anomalies such as buried metals, or structural changes to the subsurface deposits that have resulted in a change in the magnetic field (Clay 2001). The ferromagnetic object will attract the earth's magnetic field and that causes a disturbance that is useful in a magnetic survey because the magnetic signature of the disturbance results from a stronger magnetic field inside the object and a weaker field outside the object (Persson and Olofsson 2004). The related values associated with the different magnetic signatures can range from hundreds of nanoteslas, tens of nanoteslas to thousandths of nanoteslas (Gallo *et al.* 2009). Furnaces, ovens, or kilns could be expected to show readings in the hundreds of nanoteslas range (Gallo *et al.* 2009). The range for features such as roads, walls, ditches, or pits would likely be in the tens of nanoteslas, while postholes would likely be in the thousandths of nanoteslas range (Gallo *et al.* 2009).

Understanding the limitations of the data is very useful for the researcher. This next article addresses this specific issue with regards to magnetometer surveys. The authors conduct five different surveys using the same 40 by 40 meter area of previously unsurveyed land at the Lyons Bluff site in Mississippi to discuss the limitations of each survey design (Alvey *et al.* 2004). They note that geophysical data should always be collected with as high of a sampling density as possible so that the best signal-to-noise ratio and maximum resolution is achieved (Alvey *et al.* 2004). However, obtaining the highest sampling density during field work is not always practical due to time, weather, and even field conditions.

The authors of this article manipulated three main facets of the survey method, the traverse interval, traverse mode, and sample interval (Alvey *et al.* 2004). The sample interval is how often the machine takes a reading, while the traverse interval is how wide the spacing is between each transect. The traverse mode is the pattern in which the operator of the machine walks such as zig-zag or parallel. In the first survey they employed a traverse interval of 50 centimeters, a 25 centimeter sample interval, and parallel traverse mode (Alvey *et al.* 2004). The second survey employed a traverse interval of 50 centimeters, a 25 centimeter sample interval, and zig-zag traverse mode (Alvey *et al.* 2004). The third survey employed a traverse interval of one meter, a 25 centimeter sample interval, and parallel traverse mode (Alvey *et al.* 2004). The fourth survey employed a traverse interval of 50 centimeters, a 12.5 centimeter sample interval, and parallel traverse mode (Alvey *et al.* 2004). Finally for the fifth survey, they employed a traverse interval of 50 centimeters, a 50 centimeter sample interval, and parallel traverse mode (Alvey *et al.* 2004).

The highest density of sampling was obtained in the fourth survey however the limitation was the time; this survey took almost twice as long as most of the other surveys (Alvey *et al.* 2004). A second limitation in these methods of collection is the traverse mode. Zig-zag traverse modes are preferred by a lot of operators because they save time compared to parallel traverse modes. However, the zig-zag mode can cause a striping effect in the data caused by inconsistencies in the way that the machine is being held, and pace of the operator which decrease the clarity of the data (Alvey *et al.* 2004). The third, and perhaps most obvious limitation of data sampling, is the density of readings collected, the fifth survey, provided the least amount of readings while resulting in the quickest survey (Alvey *et al.* 2004).

Chapter summary

Using multiple noninvasive methods, discussed in the literature review as a framework for exploring the study site, allows the researcher to generate meaningful information without disturbing the subsurface cultural deposits and to meet the goal of stewardship. All of the methods discussed in the literature review work synergistically and allow the researcher to create a more complete picture of the study area without costly and destructive subsurface investigation.

Chapter 4

Methods

The investigation at the study site employed several different methods to gain the fullest understanding of the subsurface cultural deposits. These methods included the controlled surface survey, soil phosphate testing, and a magnetometer survey. This discussion will describe the noninvasive techniques used in the exploration of the site. The rationale behind the methods will also be discussed. The methods include the manipulation of *Surfer8*, *Excel 2003*, and *Geoplot 3.0* computer programs, data analysis, lithic identification, and mapping data for comparison.

Controlled surface survey

The first step in the investigation of the study site was a controlled surface survey conducted over two consecutive days in the spring of 2006. The survey was conducted using 55 transects spaced 4.57 meters (15 feet) apart. Every other transect was marked at 9.14 meters (30 feet) intervals to enable the surveyors to mark with reasonable accuracy, the location of artifacts collected. This grid system consisted of 9.14 meters (30 feet) by

9.14 meters (30 feet) blocks spanning the entire field (Figure 6). This was done for mapping purposes. Each of the blocks was assigned a numeric coordinate in an *Excel 2003* file which corresponds to the North and East axes in Figure 6. The *Excel 2003* file data was processed by a spatial analysis program to create various types of site maps shown in Chapter 5.

The surveyors walked in a zig-zag pattern at the same pace beginning in the southwest corner of the field and walking east so that every three transects were walked in the opposite direction as opposed to every other transect in the opposite direction. The pace was slow enough so that each surveyor was only looking to the north or south 2.28 meters (seven feet) before they were looking into another surveyor transect. This pattern was chosen in an effort to maximize visibility, reduce variability in the traverse speed, and an attempt to standardize the surveyors' maps. Hand drawn maps were used based on the grid which was laid out on the ground using a manual transit (Figure 6). The maps were as accurate as possible so that future researchers could make an attempt to replicate the data. GPS units were not used at this time because of the limitations of the researchers own project design and because of the electromagnetic interference of high voltage transmission lines which extended the full length of the eastern site border. Three surveyors participated in this controlled surface survey, each of whom carried a map so that they could plot the location of found artifacts in relation to the transect markers (Figure 7). The survey was conducted over two fairly cold overcast days.

The samples of artifacts that were collected in the survey include historic artifacts, and prehistoric lithics. Fire cracked rock (FCR) was counted and recorded but not

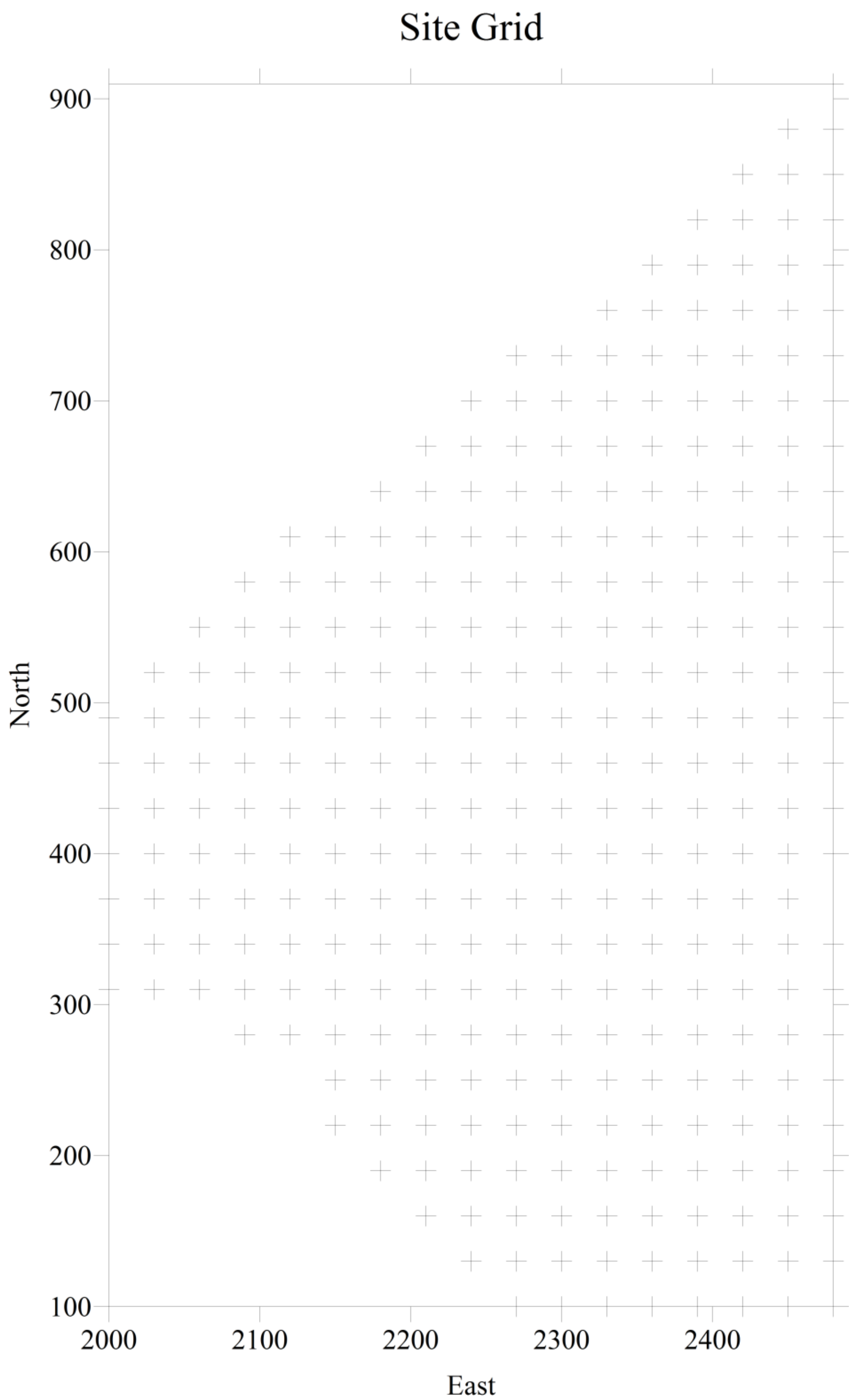

Figure 6. Site grid used during controlled surface survey and phosphate testing at the Patty Ann Farms Site. Symbols show where every other transect was marked every 9.14 meters (30 feet).

Figure 7. The property owner Mr. Miles Wyatt conducting a portion of the controlled surface survey.

collected. FCR results from using rocks to line a hearth or heating rocks for an additional heat source. Heating results in color changes and in specific heat related angular fractures. The survey was not limited to these artifacts, but pottery, ground stone tools, and other artifacts were not discernibly present on the surface of the field. The absence of pottery and ground stone tools is discussed in the results chapter. The artifacts were counted by type, and then by time period. The lithics that were identified as diagnostic were used to estimate the age based upon the age of other similarly documented artifacts (Justice 1987). The diagnostic artifacts were compared with the property owner's existing documented collection to determine similarity.

A second survey, with the property owner, was conducted on April 16, 2006. The purpose of this survey was to map the find locations of the land owner's 52 point collection that inspired this whole project. A blank map and the same flagged transects were used for this survey. During this survey, no actual transects were walked. The researcher and the property owner walked through the field with a transect map and the artifact collection to record where the property owner remembered finding the artifacts (Figure 8).

Using the collected data from the controlled surface survey and the memory survey, *Excel 2003* files were created, and the data was transferred to the *Surfer 8* program to create distribution maps. The maps show the distribution of the total artifact count, flakes and lithics, FCR, and finally the "memory map." The total artifact count includes all categories of artifacts as well as FCR found during the survey. The flakes and lithics map shows the distribution of the flakes and lithics, both diagnostic and non-diagnostic, from the pedestrian survey. The FCR map simply shows where the FCR was

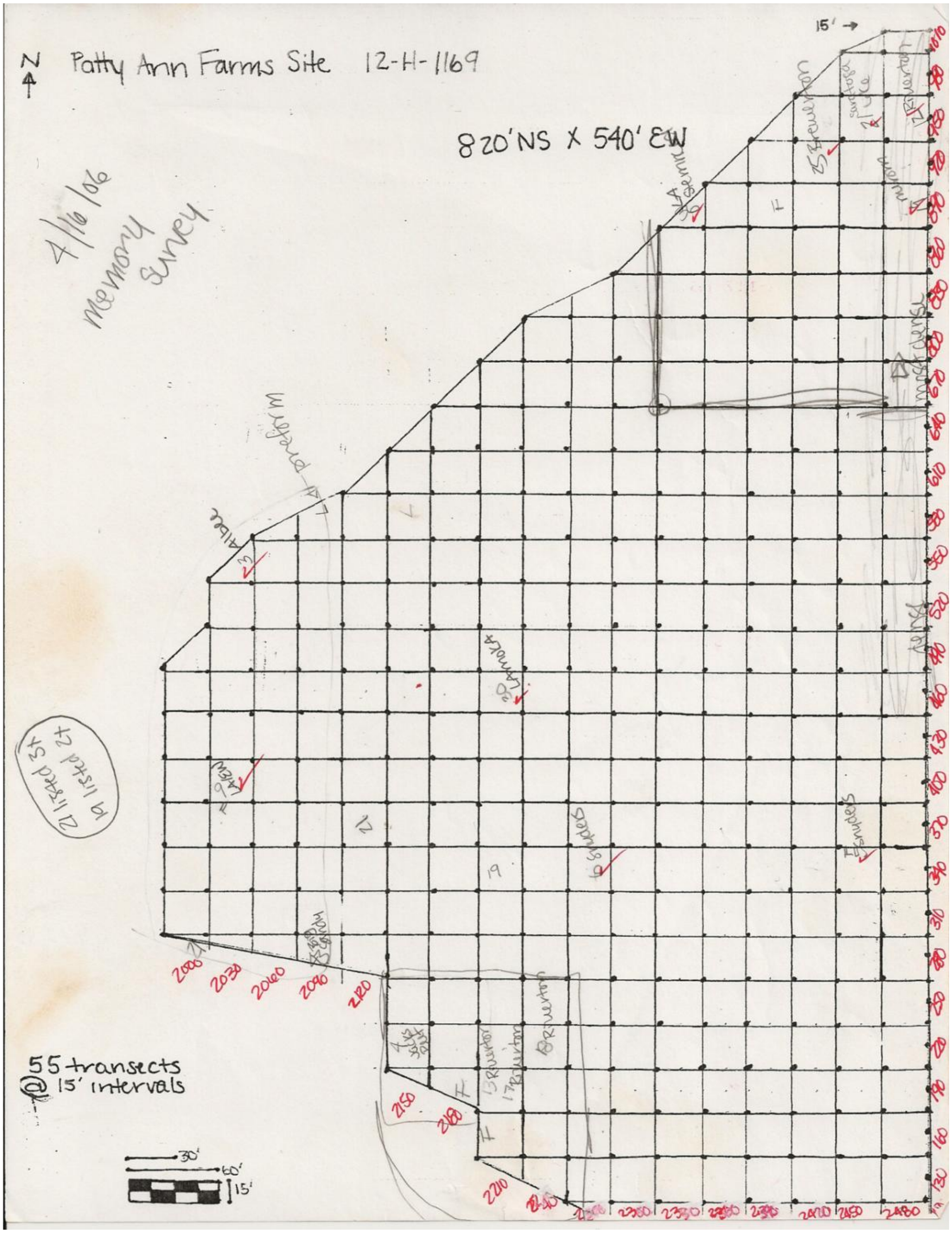

Figure 8. This is a scan of the map that was used to take notes on during the memory survey. The red numbers along the edge of this map correspond to the x, y axis of the previous maps and represent the arbitrary North, South and East, West coordinates assigned.

found and counted. The "memory map" shows the distribution of the points found by the property owner.

The points in the memory survey were recorded on the map using the last two digits of the individual catalog numbers assigned to each point. The numbers were then referenced with the table that was created to record information about each point. From the table it was possible to create a map of the artifact concentrations by prehistoric era which is located in Chapter 5.

Soil phosphate testing

After the completion of the controlled surface survey and the memory survey, and after the analysis of the data from the surveys, three areas of high artifact density were identified. These areas were then tested for the presence of soil phosphates. The preliminary test was conducted in the spring of 2007 consisting of four soil samples. One sample was taken from each of the HAD areas and one was taken from a random area. The results of the first test indicated the presence of non-fertilizer derived phosphates in all four areas. As a result of the findings from the spring 2007 phosphate test, a plan for a more intensive phosphate survey was developed. The more extensive and finer transect phosphate survey was conducted in the summer of 2007. The summer phosphate survey yielded 53 soil samples.

Using an optical transit on loan from the Applied Archaeologies Laboratories, Department of Anthropology, Ball State University, the datum from the controlled surface survey was located, and then a 9.14 meter (30 foot) by 9.14 meter (30 foot) grid was created over the entire field using pin flags to precisely relocate the high artifact density areas. Each pin flag was mapped by hand and assigned an arbitrary coordinate for tracking the samples.

The high artifact density areas were then sampled every 9.14 meters (30 feet) using a three-quarter inch Oakfield type soil sampler (Figure 9). Because of drought conditions, the soil sampler had to be driven into the ground with a sledge hammer and pulled out of the ground with a tractor. Each sample required at least 10 minutes to obtain because of the hardness of the ground. The extraction and testing methods were the same for both sets of tests, however drought conditions were not present during the preliminary tests and machinery was not necessary to obtain the samples. The hardness of the ground also influenced the density of the samples collected; a finer grained survey of 4.57 meters (15 feet) by 4.57 meters (15 feet) was not possible due to the time constraints of the project.

The soil samples were obtained from approximately 40.64 centimeters (16 inches) below the ground surface. By taking the samples from below the plow zone it is possible to create more of a controlled sample and to reduce the chance of phosphate fertilizer contamination. Each sample was individually bagged and numbered, and never touched by hand to further prevent modern phosphate contamination.

The samples were tested using a method adapted by Eidt (1973) from the Gundlach method (Shackley 1975). The Eidt method uses hydrochloric acid in place of sulphuric acid. The soils were tested by using two reagents to extract and reduce the phosphates. "Reagent A is made by adding 30 milliliters of 5 N HCL to 5 grams of ammonium molybdate completely dissolved in 100 ml of cold distilled water" (Eidt

1973:207). Reagent B is made by dissolving one gram of ascorbic acid into 200 milliliters of distilled water (Eidt 1973). Approximately 50 mg of soil or the amount held by the pointed tip of a knife blade was placed in the center of a piece of number 42 ash-free filter paper. Two drops of reagent A was added to the soil sample, and 30 seconds later two drops of reagent B was added to the same sample (Figure 10). Thirty seconds after reagent B administration, each sample was checked for the appearance of blue lines on the filter paper. A positive phosphate result was indicated by blue lines forming on the filter paper and radiating from the soil samples. All final measurements were taken at two minutes; Eidt (1973) states that within eight to 10 minutes of administering the reagents, all of the readings will begin to look the same. A stop watch was used for accuracy.

The results were ranked utilizing the scale provided in Edit's 1973 article. Nonresponsive samples were ranked as zero. Weak responses or responses that took than one minute to react and that had lines measuring less than one millimeter, were ranked as one. Lines that were approximately two millimeters long at the end of two minutes were ranked as two. Responses that reacted within a period of 30 seconds to one minute, and that had lines three to five millimeters radiating from the sample by the end of two minutes were given a rank of three. Responses that occurred within 30 seconds and that also formed lines greater than or equal to eight millimeters within two minutes were given a rank of four.

These responses were recorded on a standardized form (see Appendix B). The form recorded the date and the initials of the person performing the test, the bag sample number, data table number, length of lines radiating from the sample at the end of two

Figure 9. Jennifer Wyatt obtaining a soil sample.

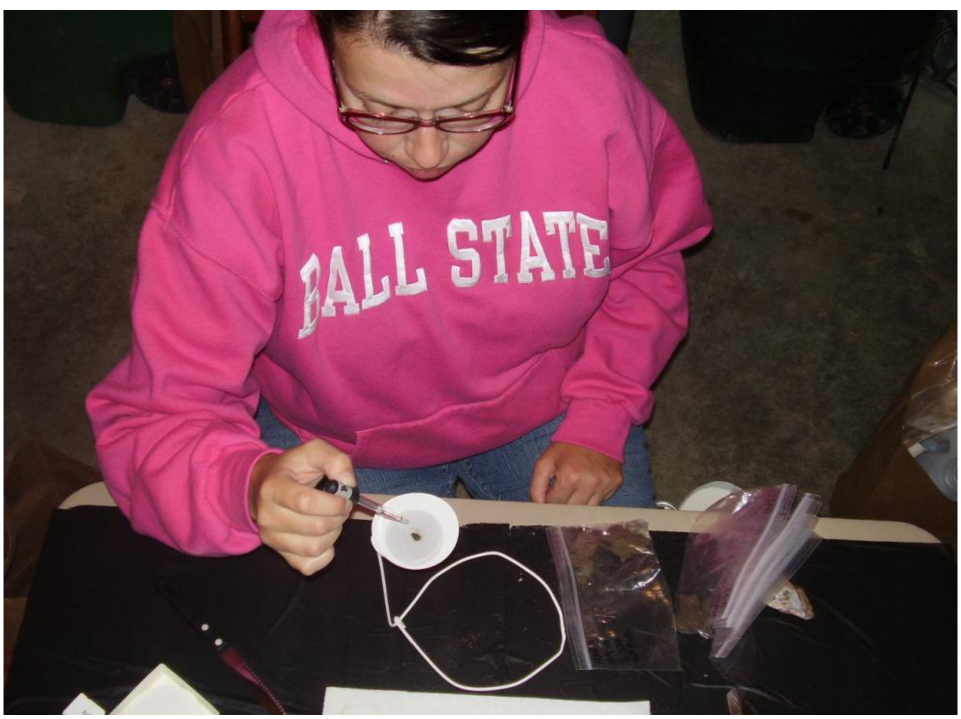

Figure 10. Jennifer Wyatt testing a soil sample.

minutes, amount of time elapsed to the appearance of lines, presence of a "ring," if apparent, and the rank of the soil sample. "Fertilizer-derived phosphate may be detected by the pale blue spot test ring, as contrasted with the dark blue lines derived from human remains" (Eidt 1973:210).

The data table numbers, as indicated on the standardized record sheet, were used to assign a value to each sample. The values were used in an *Excel 2003* worksheet. These numbers represent arbitrary easting and northing that the *Surfer 8* program needs to assign the data to a spatial reference. Care was taken to match these locations with the same arbitrary coordinates used in the controlled surface survey from 2006.

The *Excel 2003* worksheet was then imported into *Surfer 8* and maps were generated from the data. The maps demonstrated the density of the phosphate reactive tests in a location that can be referenced to an aerial photo of the Patty Ann Farms site, and to other *Surfer 8* maps such as the maps that were created from the controlled surface survey (shown in Results, Chapter 5).

Geophysical survey

As Rapp and Hill note "phosphate analysis is most useful when integrated with soil magnetic studies and geophysical surveys" (2006:123). The geophysical survey at the study site consisted of a magnetometer survey because of the correlation between the use of phosphate tests and magnetic surveys. The magnetometer survey was conducted at a much finer survey interval of one meter (3.28 feet) compared to the phosphate survey interval. This allowed for a much higher resolution in the image created by the data collected with the Fluxgate Gradiometer.

For the purposes of the magnetic testing, an FM 36 Fluxgate Gradiometer was borrowed from the Applied Archaeologies Laboratories, Department of Anthropology, Ball State University. Prior to the magnetic testing, the property owner used his own Tesoro metal detector to sweep all three high artifact density areas. The metal detector allowed for the collection and disposal of modern trash including metal pin flags that were left from previous surveys. Elimination of modern trash reduced the occurrence of false magnetic anomalies.

Preparation for the magnetic survey included establishing a grid to use as a guide for the survey transects. The grid was laid out in five meter squares using a hand transit and metric tapes (Figure 11). The grid was based off of the datum from previous site research. Once the grid was completed, hand drawn maps were created on graph paper so that notes could be made and so that progress could be tracked during the magnetic survey.

The magnetic survey was conducted over two consecutive days during September 2008. The survey transects were walked west to east and moved from north to south across the high artifact density areas. A total of eight, twenty by twenty meter grids were used for this survey. High artifact density area three was not surveyed due to the amount of magnetic noise from electrical transmission lines within this section. Transects were one meter apart with half meter intervals. This was done for time efficiency and survey accuracy. Because of the shape of the field and because of the number of no data entries or dummy logs, the manual trigger was used for the purposes of this survey (Figure 12).

Figure 11. Jennifer Wyatt laying out the survey grid.

Figure 12. Jennifer Wyatt conducting a portion of the magnetic survey.

When the survey was completed the data was downloaded and *Geoplot 3.0* was used to analyze the data. The high pass filter was used only twice on each data set of high artifact density area one and high artifact density area two, in order to clip any leftover extreme anomalies, which most likely indicate modern or historic farm debris.

Chapter summary

There are advantages to utilizing multiple, non-destructive, methods of archaeological survey. Each method in and of itself provides essential archaeologic data. However the combined derived data from each noninvasive method provides a synergy of site information. These methods provide opportunity to meet the goals of site stewardship and preservation, and of contributing to the archaeological record without excavation.

The controlled surface survey is the easiest to implement. Even though it is the easiest to implement, the surface survey must be planned. The surface survey requires a surveyor, site map development, a method of recording artifact location, and a means to label and collect surface artifacts.

The next method of subsurface phosphate testing requires a little more planning and some knowledge of chemistry is helpful. When the surveyor performs the tests, special permission for acquiring the hazardous reagents and other chemicals must be included in the planning. A laboratory site, lab equipment, scales, timer and other equipment are also necessary. A project budget should be included with this type of research design.

The third method of magnetic gradiometer survey also requires mapping and planning. Part of the plan requires learning to properly use the equipment and a familiarity with computer programs needed to process the acquired data.

The location of diagnostic artifacts provides valuable data regarding the site. Phosphate testing answers other questions that are not apparent in a surface survey. The presence of organic phosphates reveals quantitative information about subsurface soils. Magnetic gradiometry demonstrates the presence of possible subsurface artifacts such as hearths, foundations, and other structures based on the nanotesla readings from magnetic anomalies recorded by the equipment.

The combined results can stand alone or can suggest avenues for further testing and research.

Chapter 5

Results

The purpose of this chapter is to discuss the results of the multiple methods used in this project. The results of each method are presented in this chapter. The data is also presented in the form of Figures that display the correlation of the concentrations of the results within the study area. These visual results are to demonstrate the horizontal and to some degree, the vertical extent of the data in each of the HAD areas.

Controlled surface survey

The results from the controlled surface survey yielded 318 artifacts. However, 259 of those artifacts were fire-cracked rock (FCR). FCR can indicate human activity. If the FCR was produced by human activity, then these artifacts are associated with prehistoric hearths. Rocks used in prehistoric cooking were heated to boil water and would crack during heating and cooling. Other artifacts found included 34 flakes, four diagnostic points, two unidentifiable point fragments, three scrapers, and 15 historic artifacts. The diagnostic points included two Early Archaic points, one Late Archaic, and one Early Woodland point. These points concur with the known time span of projectile points that were collected from the site by the property owner. No pottery artifacts were found.

The study site lies partially within a flood plain. Parts of the field are submerged annually when Pipe Creek floods. Flooding and continuous cultivation are likely reasons as to why pottery and ground stone tools are not represented in the artifact assemblage. Generally, people do not settle where floods occur. The historic artifacts consisted of a partial horse shoe, an odd piece of metal, what appears to be a portion of a buckle, and some glass and ceramic shards. Some of the historic artifacts may have been deposited as trash following the path of the highway (Figure 13). Some of the older fragments may be relics associated with cultivation. All of the glass was collected near the highway.

The data collected during the controlled surface survey was used to generate several maps as discussed in Chapter 4 (Figures 14, 15 and 16). The same maps were used during the next two surveys to help delineate the high artifact density areas so that the property owner could keep majority of the field in cultivation to minimize fiscal loss. Three areas of high artifact density were chosen for further research and were taken out of cultivation. This was done to prevent crop damage when the soil samples were obtained and to prevent site disturbance during subsequent magnetometer surveying.

The first map created depicts the overall results of the controlled surface survey and the recovery locations of the diagnostic lithics. The first map is illustrated in Figure 14. When looking at this map it is possible to pick out areas of interest that were not selected as part of the HAD areas, these may be of interest in future investigations. The HAD areas were selected based on the overall size and concentration of artifacts present in the controlled surface survey. The next maps created were more specific and delineated the extent of artifact scatters. Figure 15 shows the overall distribution of the flakes and lithic artifacts recovered, while Figure 16 shows the overall distribution of the FCR within the site. Figure 17 depicts the concentrations of lithics by prehistoric era. The yellow represents Archaic, with lighter yellow being earlier than darker yellow. Green represents late archaic early woodland transition, and blue represents woodland era lithics. This map is useful in visualizing where the different eras are located.

Early Archaic. The Early Archaic points (Figure 18) have been identified as LeCroy (Justice 1987), and a smaller variety of Kirk Corner Notched (Justice 1987). The LeCroy point (Justice 1987) is a base fragment still retaining the diagnostic basal notching and shoulders that make it resemble a star, although the point tip that would complete the star is missing. LeCroy points (Justice 1987) are widespread in the Eastern United States including Indiana. The range appears to span from the East coast to parts of Missouri and from northern Alabama and Georgia to southern Michigan (Justice 1987). LeCroy points have an associated date that ranges from 6,500 to 5,800 BC (Justice 1987).

The Kirk Corner Notched point (Justice 1987) is a complete point, and exhibits denticulated edges. The point is diagnostic of the Early Archaic and has an affiliated date of 7,500 to 6,900 BC (Justice 1987). The geographic range associated with this point contains most of the eastern United States from the Atlantic coast to Missouri and parts of Texas, and the Gulf coast to southern Michigan and New York (Justice 1987).

Late Archaic. The Late Archaic point (Figure 19) is a complete Lamoka point (Justice 1987). It was a difficult point to assign to a type because it does not appear as

Figure 13. Historic artifacts recovered from the controlled surface survey.

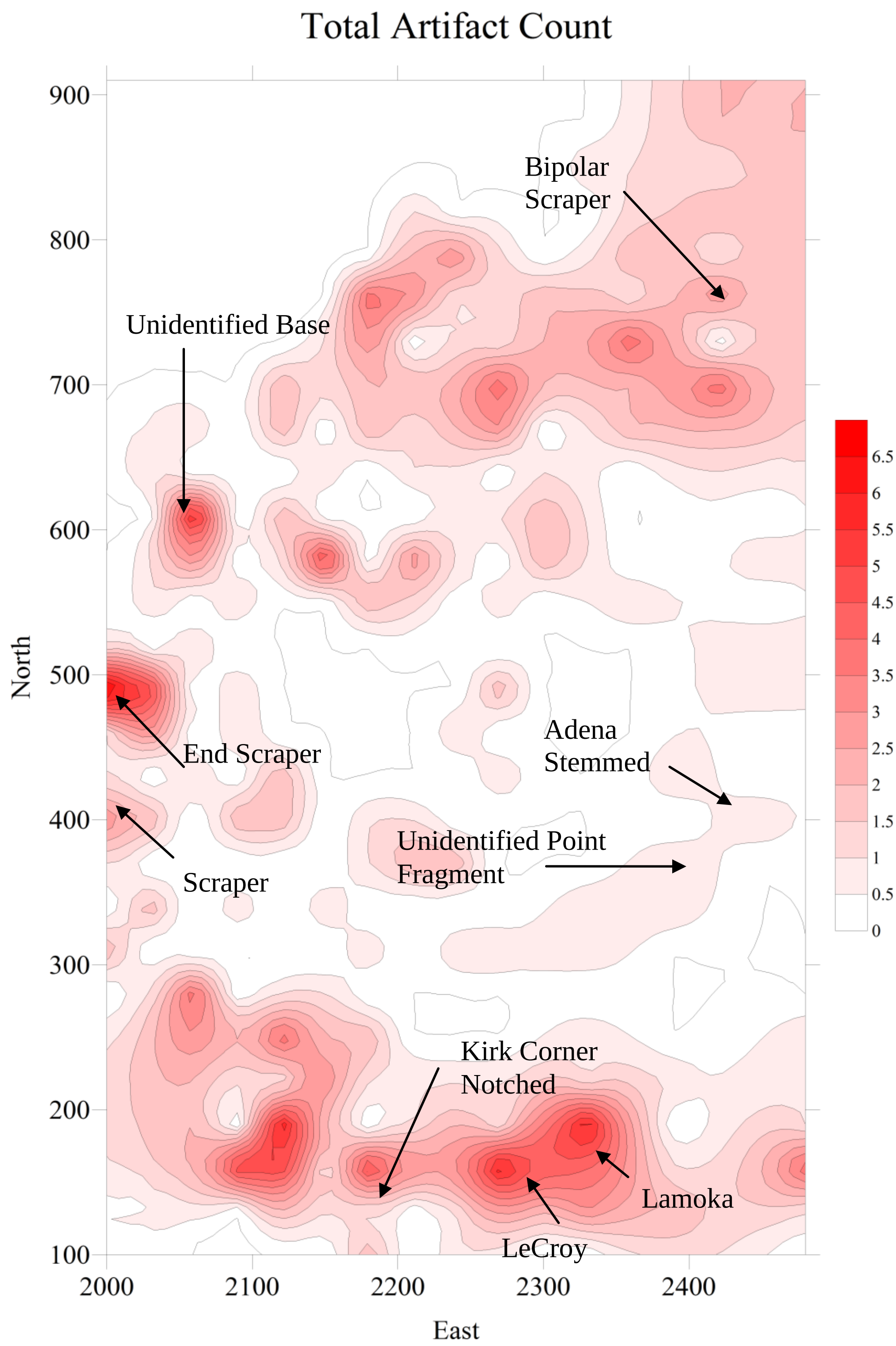

Figure 14. Map showing the results of the controlled surface survey. This map represents the total artifact count data in *Surfer 8*. The scale represents the density of artifacts, from zero to more than six.

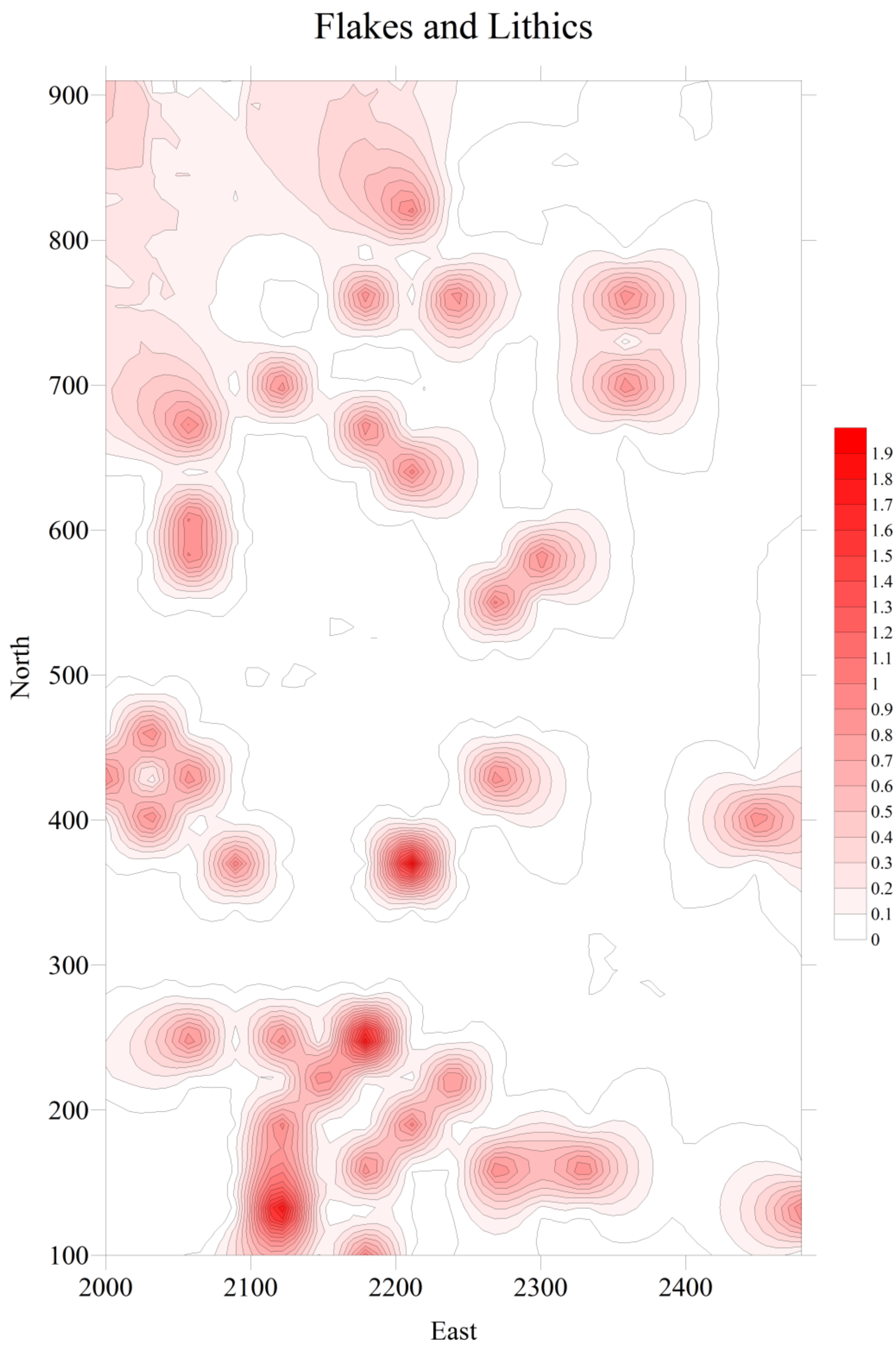

Figure 15. Map showing the results of the flake and lithic artifact count data in *Surfer 8*. The scale represents the density of artifacts, from zero to two.

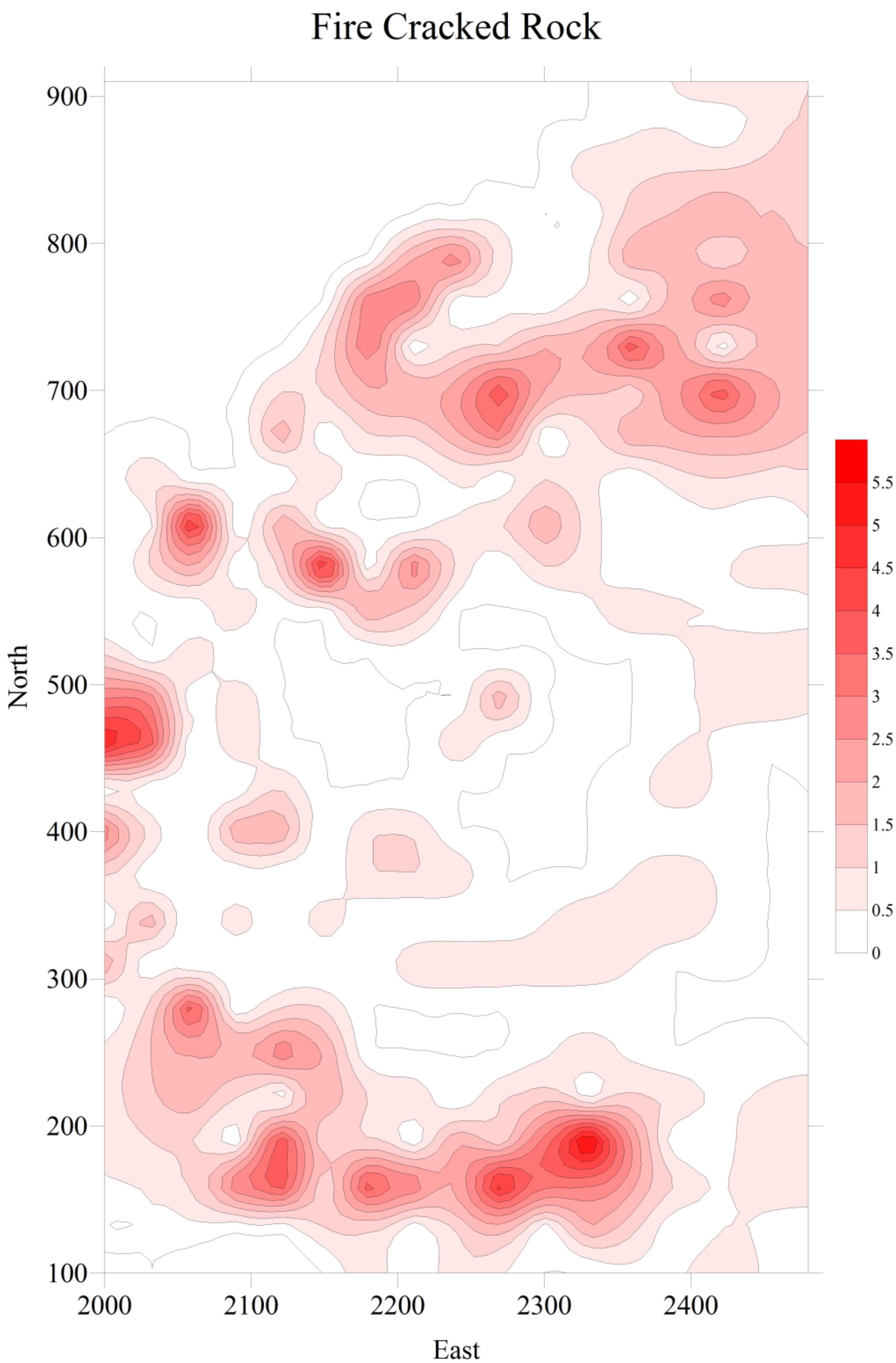

Figure 16. Map showing the fire cracked rock count data in *Surfer 8*. The scale represents the density of artifacts, from zero to more than five.

other Lamoka (Justice 1987) points from the property owner's collection. The lithic matches the measurements found in the Justice book (1987), as well as matching the physical description; however it is much thicker than a typical Lamoka point. The age affiliated with Lamoka ranges from 3,500 to 2,500 BC (Justice 1987). The geographic distribution of Lamoka points (Justice 1987) covers the northern Midwest and extends out to the East Coast.

Early Woodland. The Early Woodland point (Figure 20) is an Adena Stemmed (Justice 1987) fragment. Although the point is missing the distal end, a sufficient portion of the base provided enough to classify. The associated dates for Adena Stemmed points (Justice 1987) range from 800 to 300 BC. Adena people are culturally associated with mound builders. The geographic range for this point type covers the entire Midwest and spans into the Great Lakes region down to the Gulf coast, including parts of Florida (Justice 1987).

Unidentifiable point fragments. The unidentifiable point fragments (Figure 21) are not diagnostic of any specific time period because incomplete lithics cannot be assigned to a point type. The fragment a (Figure 21) is missing the base and the shoulders are simply too fragmented to assign a type. The overall shape of the point resembles a Snyder's point (Justice 1987). The fragment b (Figure 21) is a point base which would be hafted onto the shaft of a spear. The base exhibits basal grinding.

Scrapers. The three scrapers were interesting, since each were made from different materials and were crafted with different knapping techniques. The scraper a (Figure 22) is an end scraper and would most likely have been hafted onto a piece of bone or to a handle of some sort. The scraper b (Figure 22) is a bifacial scraper that has

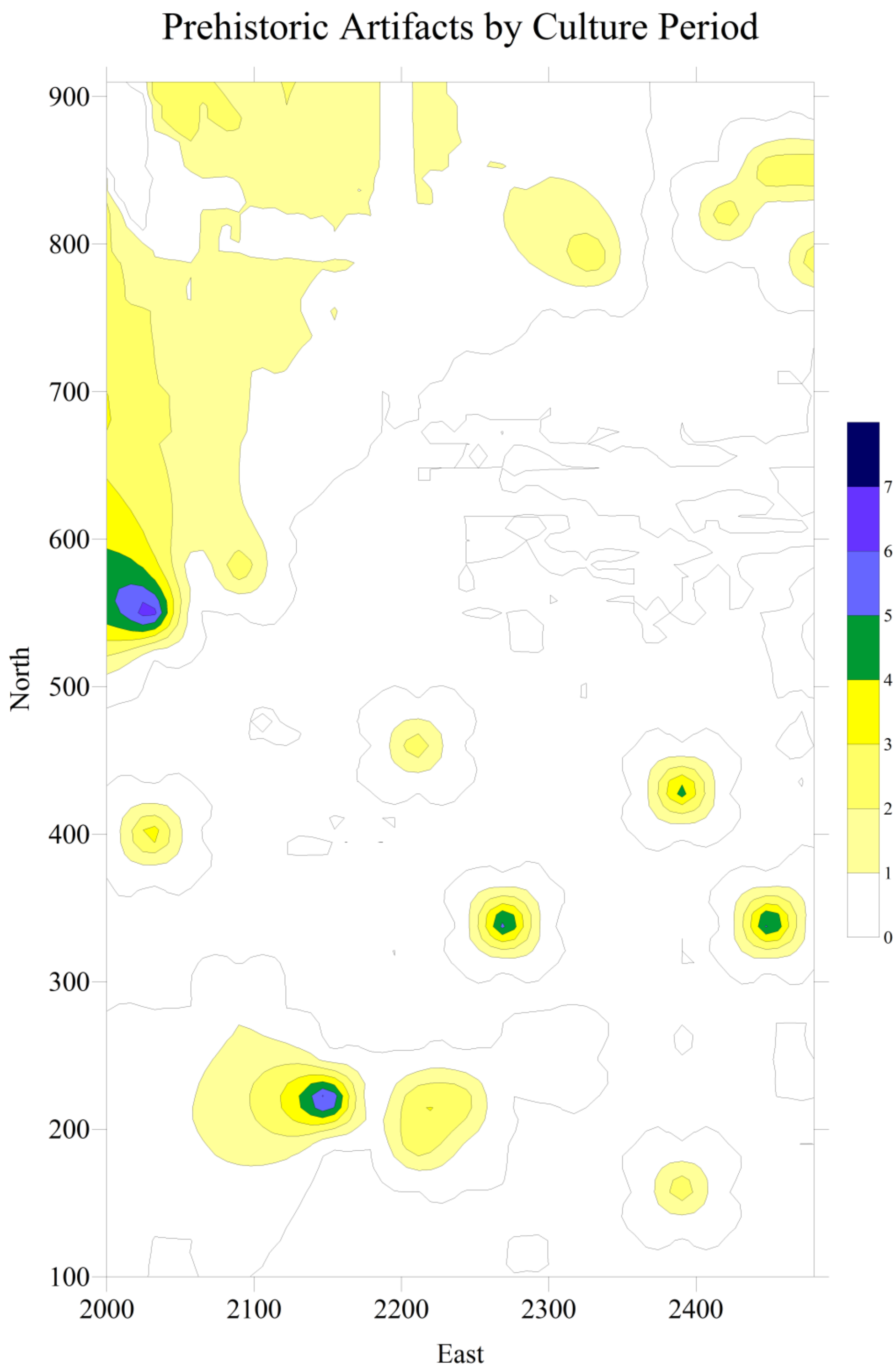

Figure 17. This map depicts the concentrations of lithics by prehistoric era. The yellow represents Archaic, with lighter yellow being earlier than darker yellow. Green represents late archaic early woodland transition, and blue represents woodland era lithics.

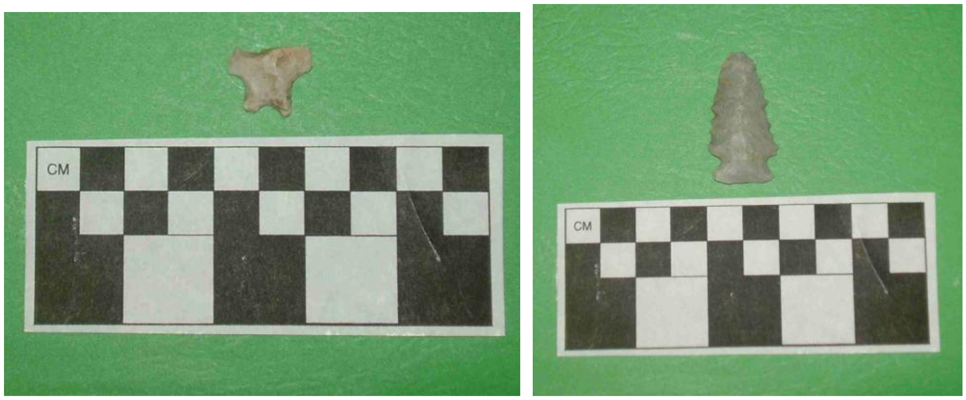

Figure 18. From left to right, LeCroy fragment and Kirk Point, found during the survey at the study site.

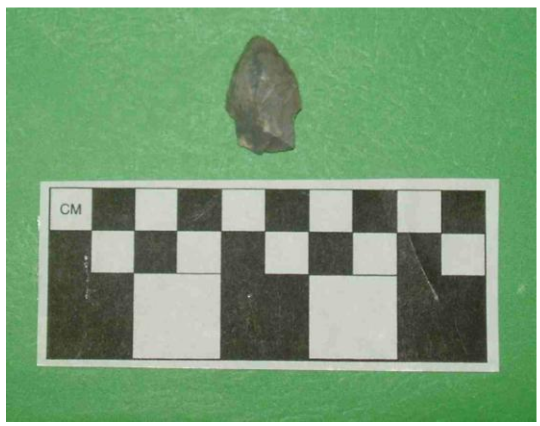

Figure 19. Lamoka point from the survey at the study site.

Figure 20. Adena Stemmed fragment from the survey at the study site.

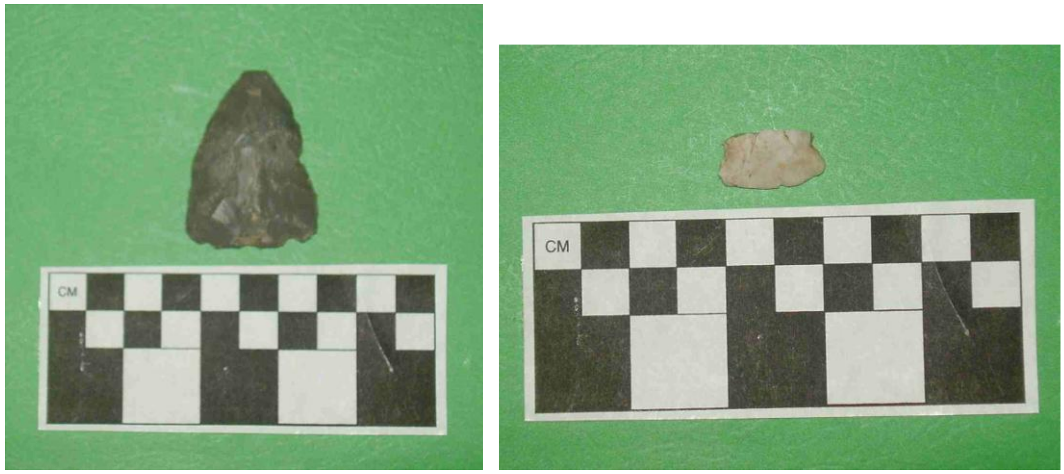

Figure 21. From left to right, fragments a. and b. found during the survey at the study site.

Figure 22. From left to right: a. End Scraper, b. Side scraper, and c. Bipolar Scraper from the survey at the study site.

been modified along one edge to sharpen it. The scraper c (Figure 22) is made with bipolar technology. This means that the piece was fractured by placing it on an anvil stone and hitting it with another rock. This creates flake scars that run in opposite directions.

Soil phosphate testing

The results of the soil phosphate tests were exciting (Figure 23). Out of 53 samples, 20 of the samples or 38 percent were nonresponsive earning a rank of zero. “Weak” responses included 14 samples, or 26 percent, while “regular” responses accounted for four samples, or 8 percent. An additional 20 percent or 11 responses ranked in the “good” range. Finally, a total of four “strong” responses were recorded comprising eight percent of the samples. The presence of rings indicating phosphate fertilizer contamination was not observed, which indicates that fertilizer contamination is not a factor in the results of these tests.

The strongest responses were observed in HAD3. All four of the “strong” responses were from this area and accounted for 16.5 percent of the HAD3 observations. HAD3 was the largest in size and 24 samples were taken from this location. The major difference between HAD3 and the other areas is that the biggest percentages of responses were in the “weak” range as opposed to the nonresponsive range. Nonresponsive was actually second in frequency for this area. “Regular” response measurements accounted for 16.5 percent of the samples from HAD3. It is interesting to note however, that HAD3

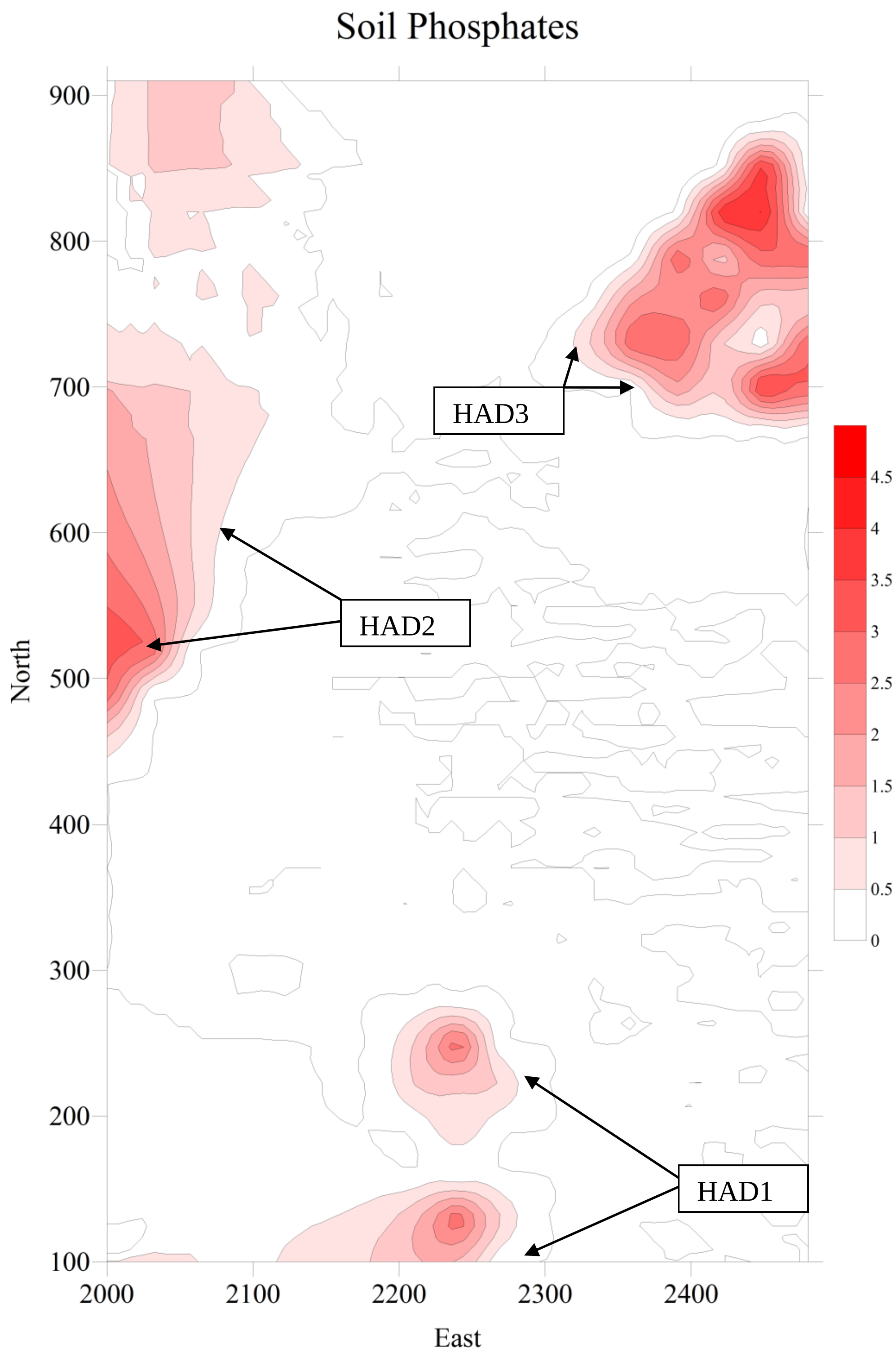

Figure 23. Results from the phosphate survey shown in a *Surfer 8* density map, the red areas indicate the presence of phosphates. Responses were ranked from zero to four based on the time elapsed while the reagents reacted, refer to page 35.

is flooded almost annually. While the new sediment and water is not the likely reason behind the strong responses because the phosphates are tightly bonded to the sediment where they are initially deposited resulting in little movement (Leonardi *et al.* 1999). It is, however, worth noting that because of the annual depositional nature of a flood plain the sample depth of 40.64 centimeters (16 inches) below the ground surface may not be as old of a layer of sediment as in HAD1 or HAD2. Additionally, no ecofacts such as animal bone were collected or noted in any of the surveys.

HAD2 the smallest in size and only 12 samples were taken from this area. Sixty seven percent of those samples were nonresponsive. An additional 16.5 percent of the samples were weak responses, and 16.5 percent were "good." The responsive samples were clustered around the northwest edge of the site, as noted by the density of the contour lines in Figure 23.

HAD1 is the southernmost area. The majority or 53 percent of the samples in HAD1 were nonresponsive. However, 35 percent were "weak," and 12 percent of the samples were ranked "good." The responses for HAD1 are clustered in two locations which were the northeast and southeast regions of HAD1 delineation.

Geophysical survey

The fluxgate gradiometer measures the earth's magnetic field. A nanotesla is one billionth of a tesla. A tesla is the unit of measure for magnetic field strength. The results of the magnetic survey at the study site were encouraging. However, there were no large atypical anomalies present nor were there any series of small suspicious anomalies demonstrated (Figures 24 and 25). There are a few anomalies in each of the high artifact density areas that might be worth investigating. In HAD1 there are two areas with readings that are around six and seven nanoteslas which appears to be within the range of acceptable readings for a prehistoric site. There are several other anomalies with a higher nanotesla reading. These readings however measured a very high 38.72 nanoteslas and were associated with a white halo or dipole effect which is when there is a strong reading followed by a weak reading creating a black spot with an adjacent white halo or spot. This indicates that the signals produced were probably modern trash.

One large anomaly in HAD2 and several smaller ones appear to possibly be historic trash. However, there is one sizeable anomaly that is about 13.14 nanoteslas, which is in the acceptable range for a prehistoric site and is similar to the range of readings found in other nearby sites. These results were then compared to the results from the soil phosphate tests (Figure 23). A comparison of the results, plotted on the maps, demonstrates that there is a correlation between the anomalies of the magnetic survey and between the reactive areas from the phosphate tests.

When two different methods define anomalies in the same location it is likely that the subsurface results will be cultural. The fluxgate gradiometer defined anomalies in HAD1 and HAD2 where the soil phosphate survey also indicated high phosphate levels. This can be interpreted as cultural because the magnetic signature of the anomalies is in the tens of nanoteslas range which could possibly indicate a posthole or similar structure (Gallo *et al.* 2009) and the phosphate levels present below the plow zone indicate organic phosphates. In addition, the high artifact density areas are correlated with the phosphate

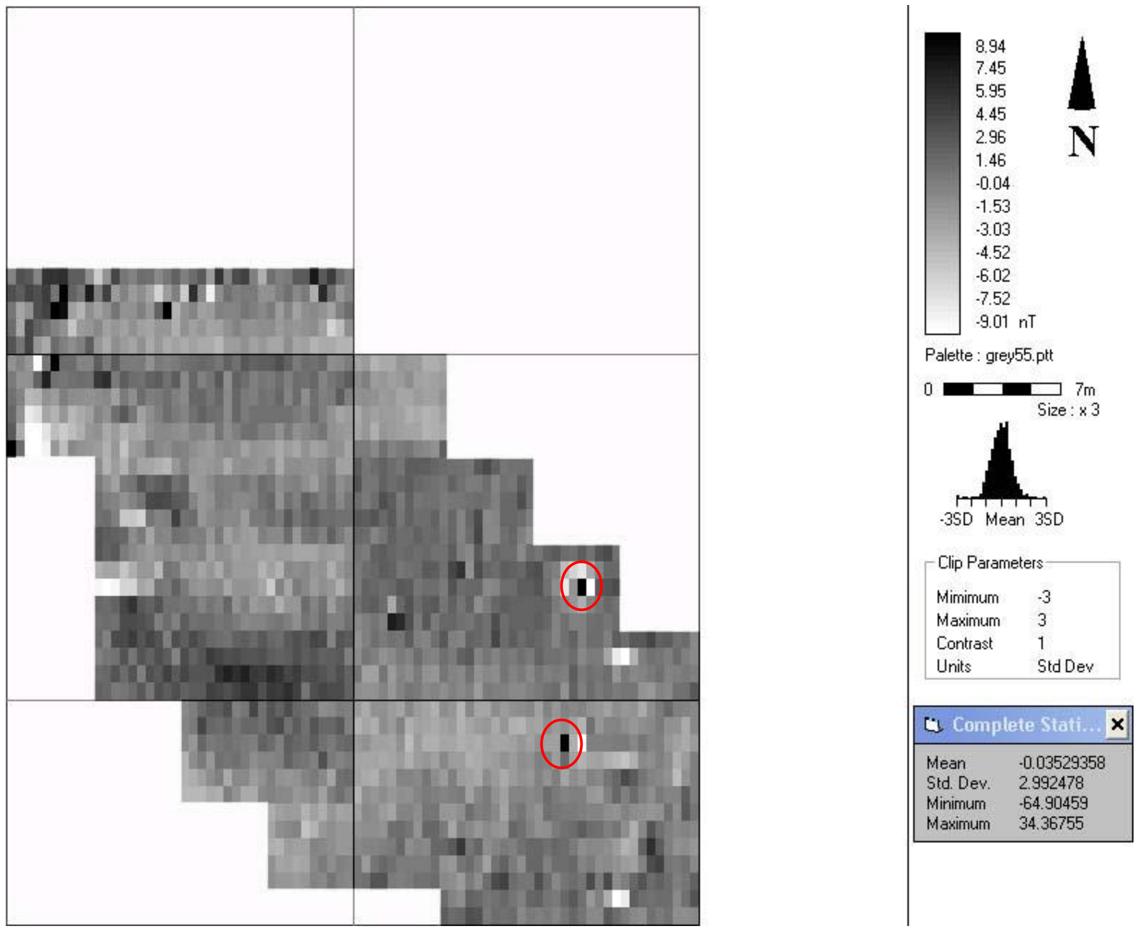

Figure 24. Magnetometer results on *Geoplot 3.0* for HAD1, the red circles indicate the notable anomalies. The scale represents the measurements taken in nanoteslas.

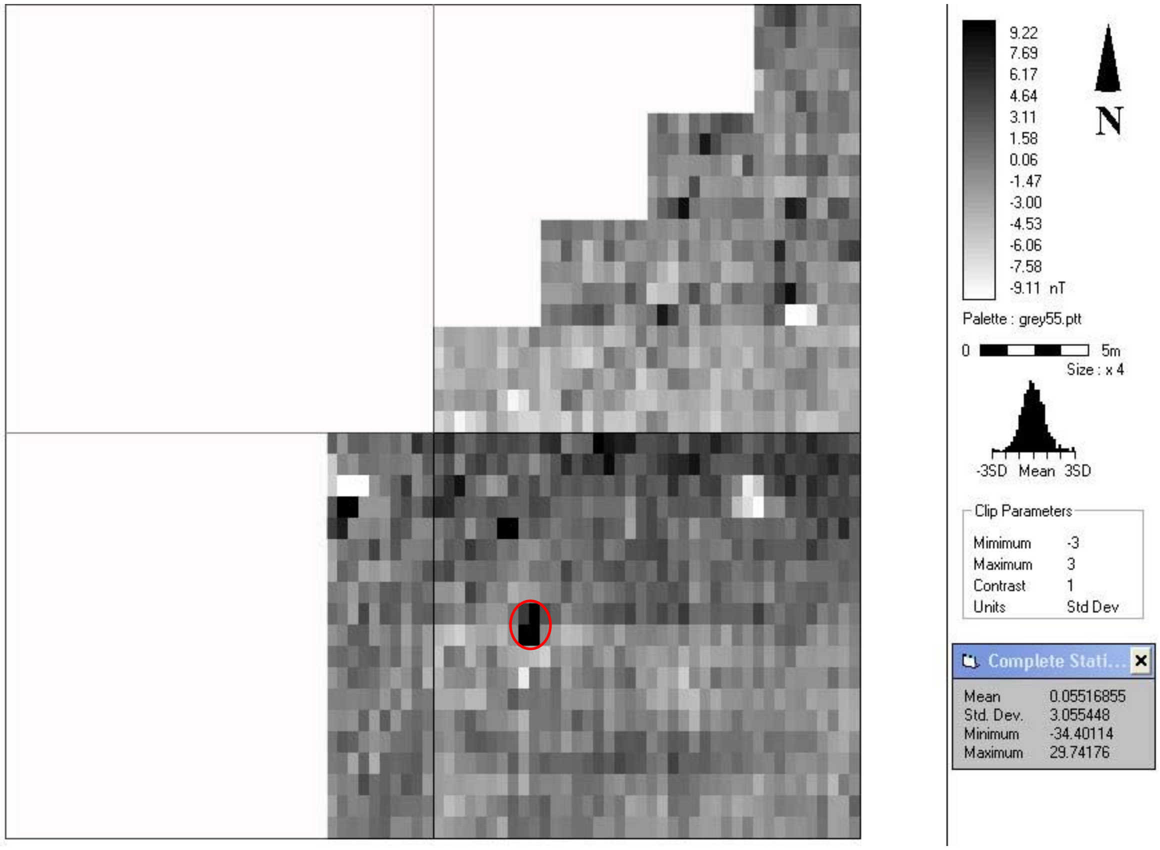

Figure 25. Magnetometer results in *Geoplot 3.0* from HAD2, the red circles indicate the notable anomalies. The scale represents the measurements taken in nanoteslas.

and magnetic test results because of the abundance of surface artifacts present during the controlled surface survey.

Chapter summary

The magnetic gradiometer, in conjunction with subsurface phosphate testing, and a controlled surface survey, provides a type of image of subsurface artifacts. Utilization of these methods in a research design strengthens the results of data agreement. If there are areas of agreement, then anomalous areas are likely a subsurface cultural remnant as opposed to a naturally occurring disturbance. This reinforcement of agreement occurred during this survey, which exemplifies the utility of using multiple methods when advocating both stewardship and integrity of sites. The data agreement is further discussed in Chapter 6.

Chapter 6

Conclusion

The purpose of this chapter is to compare the methods utilized during this study and synthesize the results based on the data presented in Chapter 5. This thesis demonstrated the use of several noninvasive techniques for archaeological survey, this chapter will use the derived data, and the context of the data to discuss the utility of these methods for similar projects. Because of time and space constraints certain limitations were applied to the data that may not always exist. An example of limitation would pertain to sites located outside of cultivated fields that may not have to reduce their survey area until mitigation of the site requires subsurface investigation. Based on the information gathered during the research for this thesis, the data presented in this chapter will be used to help plan the future investigations at the study site.

Controlled surface survey

Based on the results from the formal pedestrian survey *Surfer 8* maps, three areas have been identified as containing the highest concentration of surface artifacts. These areas of higher density lithic scatter were chosen for further investigation utilizing phosphate and magnetic gradiometer testing because the landowner was still cultivating the field. Compiling *Surfer 8* maps results, from the pedestrian survey, is an important phase of the project because it allows the archaeologist to create a map which then forms a basis for deciding which areas require further investigation. This method established the horizontal extent of the surface artifact distribution, and based on the careful mapping of the survey, the results should be less variable than a simple pedestrian survey. This method also produced the largest number of data. However, it is the opinion of the researcher that the total number of fire cracked rock (FCR) found is in error due to surveyor error. It is likely that the experience, or lack thereof, on the part of the field crew played a role in the nondiscretionary recording of FCR.

The second phase of the pedestrian survey was the memory survey. It was hypothesized that the property owner would be able to remember where he found the majority of the artifacts. The result of this phase is that there is now a map of the project area which exhibits high artifact concentration and which concurs with the areas where the property owner frequently collected. The controlled surface survey located several diagnostic as well as nondiagnostic and historic artifacts.

Soil phosphate testing

The results of the phosphate tests and the spatial distribution of responsive samples indicate that the most responsive area is HAD3, followed by HAD2, and HAD1. According to the results of the controlled surface survey from the spring of 2006, the highest density of artifacts was found in HAD1 followed by HAD2, and HAD3. The only constant between the two surveys was that HAD2 remained the middle sample. However, environmental variability may be the cause of the strongest phosphate responses in HAD3. High artifact density area three is alluviated annually and it is more probable that the buried sources of the phosphate responses in this HAD are from alluvial deposits.

Geophysical survey

The magnetic survey indicates a much more refined area of possible interest within HAD1 and HAD2. The phosphate tests seem to reinforce the original controlled surface survey which agreed with the information provided by the land owner, in addition the magnetic data agree with the phosphate tests (Figure 26). However, the results of the phosphate tests and of the magnetic tests show that the study site is an area of interest for further investigation. Additional investigation methods could include electric resistivity, qualitative phosphate testing, pH testing, or even subsurface investigations.

Chapter Summary

The goal of this thesis is to examine the Patty Ann Farms Site and to provide accurate and comprehensive information on the methods of geophysical archaeology used at the study site, and to use the research data to meet the goals of stewardship.

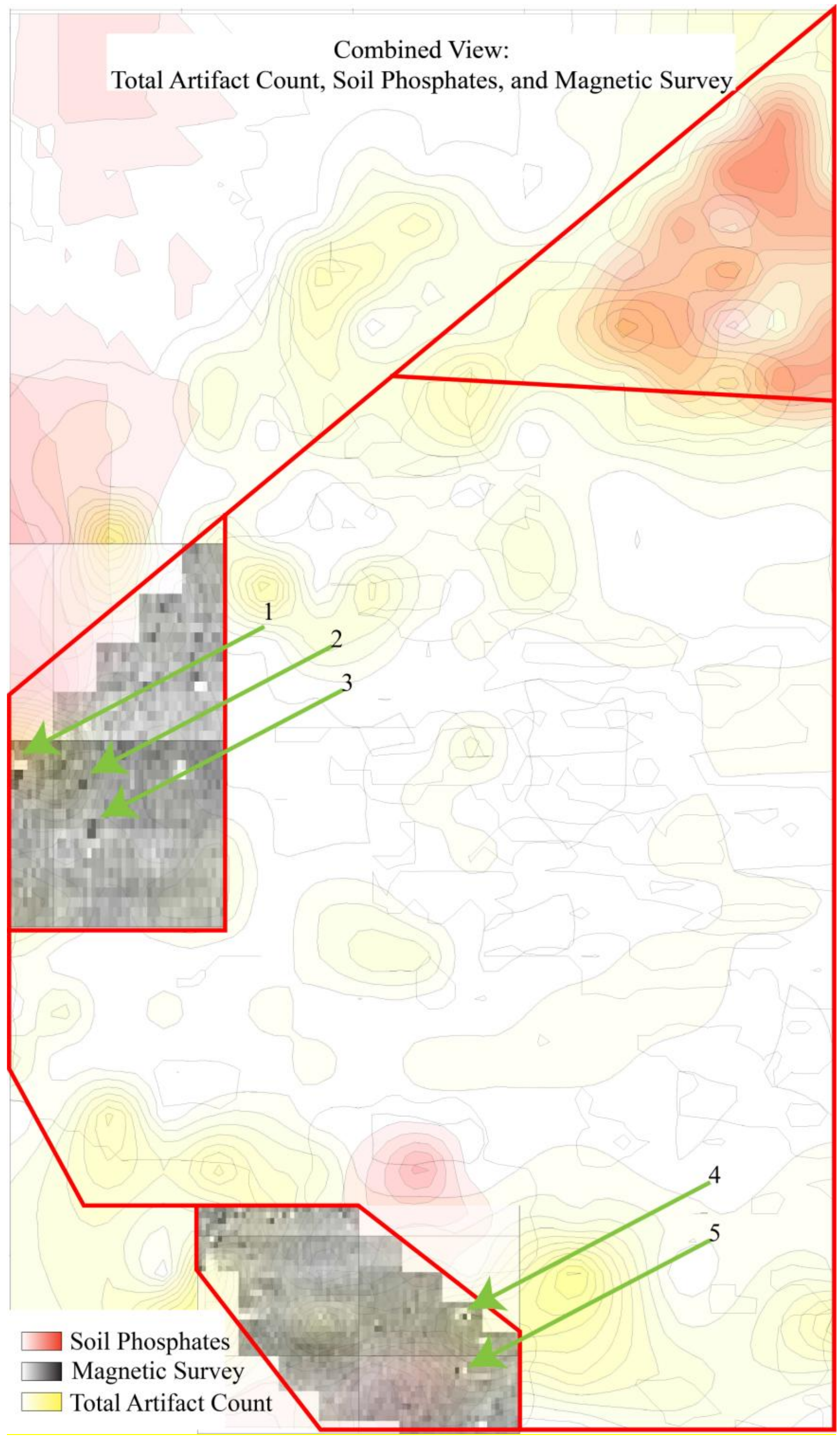

Figure 26. This Figure is showing the total artifact count from the controlled surface survey in yellow, the phosphate testing results in red, and the magnetometer results in grayscale. The green arrows are pointing to areas of interest. The only area that agrees in all three surveys is by the number one arrow.

This thesis contributes to the current state of knowledge for the archaeology of Hamilton County, Indiana, and provides information relative to cultural resource management for data storage and analysis. This thesis attempts to provide a thorough and useful literature review for several methods including controlled surface surveys, memory surveys, and magnetometry in addition to case studies employing these methods. Additionally, this thesis contributes to Indiana archaeology and to Midwest archaeology in general.

Archaeologically, the study site is an important site for Hamilton County, and for all of Indiana because of the level of complexity that is evident thus far. The temporal span of this site is demonstrated by diagnostic artifacts ranging from Paleo-Indian through terminal Late Woodland. Several components from each cultural period are represented, and in many instances several diagnostic types of each component have been recovered. This site has the potential to provide much archaeological data and to help answer questions regarding the regional prehistory. Preserving the site by using multiple noninvasive techniques lends to the integrity of the site for future research. As research methods become less invasive in archaeology, the stewardship of sites becomes a bigger responsibility for not only the archaeologist, but researchers, local residents, and descendant communities.

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APPENDIX A

The information contained in this section is the information that was recorded about the property owner’s collection. The table is the description of all the points as far as the type, period, approximate age, and raw material. The table is followed by the photographs of the property owner’s collection of projectile points grouped by cultural period.

Identified Artifacts	Period	Description	Reference	Age	Raw Material	Catalog Number
Point	Late Prehistory	Triangle Cluster	Justice 224	AD 800- start of historic	Fall Creek Chert	12-H-1169-1
Point	Late Woodland	Albee	Winters	AD 1000	Fall Creek Chert	12-H-1169-2
Point	Late Woodland	Albee	Winters	AD 1000	Fall Creek Chert	12-H-1169-3
Point	Late Woodland	Jacks Reef	Justice 217	AD 500-1200	Fall Creek Chert	12-H-1169-4
Point	Middle Woodland	Snyders	Justice 201	200 BC- AD 400	Wyondo tte	12-H-1169-5
Point	Middle Woodland	Snyders	Justice 201	200 BC- AD 400	Fall Creek Chert	12-H-1169-6
Point	Middle/ Early Woodland	Robbins	Justice 187	500 BC- AD 200		12-H-1169-7
Point	Early Woodland	Early Woodland Stemmed	Justice 184	500 BC	Fall Creek Chert	12-H-1169-8
Point	Early Woodland/ Late Archaic	LA/EW Type Unclassified	n/a	ca 1500-200 BC		12-H-1169-9
Point	Early Woodland/ Late Archaic	Delhi Like	Justice 179	1300-200 BC		12-H-1169-10
Point	Early Woodland/ Late Archaic	Buck Creek	Justice 183	1500-600 BC		12-H-1169-11
Point	Late Archaic	Riverton Preform	Winters 105 P14	1500-1000 BC		12-H-1169-12
Point	Late Archaic	Riverton	Winters 105 P14	1500-1000 BC		12-H-1169-13
Point	Late Archaic	Riverton	Winters 105 P14	1500-1000 BC		12-H-1169-14
Point	Late Archaic	Riverton	Winters 105 P14	1500-1000 BC		12-H-1169-16
Point	Late Archaic	Riverton	Winters 105 P14	1500-1000 BC	Fall Creek Chert	12-H-1169-17
Point	Late Archaic	Riverton	Winters 105 P14	1500-1000 BC	Fall Creek Chert	12-H-1169-18
Point	Late Archaic	Merom Expanding Stem	Justice 130	1600-1000 BC		12-H-1169-19
Point	Late Archaic	Snook Kill Like	Justice	1800-1600		12-H-

			159	BC		1169-20
Point	Late Archaic	Saratoga Like	Justice 154	2000 BC		12-H-1169-21
Point	Late Archaic	Saratoga Like	Justice 154	2000 BC		12-H-1169-22
Point	Late Archaic	Brewerton	Justice 115	2980-1723 BC		12-H-1169-23
Point	Late Archaic	Brewerton	Justice 115	2980-1723 BC	Fall Creek Chert	12-H-1169-24
Point	Late Archaic	Brewerton	Justice 115	2980-1723 BC	Attica	12-H-1169-25
Point	Late Archaic	Table Rock Cluster	Justice 124	3000-1000 BC	Fall Creek Chert	12-H-1169-26
Point	Late Archaic	Lakoma	Justice 127	3500-2500 BC		12-H-1169-27
Point	Late Archaic	Lakoma	Justice 127	3500-2500 BC	Wyondo tte	12-H-1169-28
Point	Late Archaic	Lakoma	Justice 127	3500-2500 BC	Fall Creek Chert	12-H-1169-29
Point	Late Archaic	Lakoma	Justice 127	3500-2500 BC	Fall Creek Chert	12-H-1169-30
Point	Late Archaic	Matanzas Side Notched	Justice 119	3700-3000 BC	Unknow n	12-H-1169-31
Point	Late Archaic	Matanzas Side Notched	Justice 119	3700-3000 BC	Fall Creek Chert	12-H-1169-32
Point	Late Archaic	Matanzas Side Notched	Justice 119	3700-3000 BC	Attica	12-H-1169-33
Point	Late Archaic	LA Stemmed	Justice 133	3700-3000 BC	Fall Creek Chert	12-H-1169-34
Point	Late Archaic	LA Stemmed	Justice 133	3700-3000 BC	Fall Creek Chert	12-H-1169-35
Point	Late Archaic	LA Stemmed	Justice 133	3700-3000 BC	Fall Creek Chert	12-H-1169-36
Point	Late Archaic	LA Stemmed	Justice 133	3700-3000 BC		12-H-1169-37
Point	Middle Archaic	Amos	Youse	4790-4365 BC		12-H-1169-38
Point	Early Archaic	Kirk Stemmed	Justice 82 & Broyles	6900-6000 BC		12-H-1169-39
Point	Early Archaic	Kirk	Justice 71	7500-6900 BC		12-H-1169-40
Point	Early Archaic	Kirk Corner Notched	Justice 71	7500-6900 BC	Attica	12-H-1169-41
Point	Early Archaic	Kirk Corner Notched	Justice 71	7500-6900 BC		12-H-1169-52

Point	Early Archaic	Graham Cave Side Notched	Justice 63	8000-5500 BC		12-H-1169-42
Point	Early Archaic	Big Sandy	Justice 62	8000-6000 BC		12-H-1169-43
Point	Early Archaic	Thebes Cluster	Justice 54	8000-6000 BC		12-H-1169-44
Point	Paleo Indian	Agate Basin	Justice 33	8500-8000 BC		12-H-1169-45
Point	Paleo Indian	Late PaleoIndian	Prufer	ca 8000-8500		12-H-1169-46
Point	Paleo Indian	Late PaleoIndian Lancolet	Prufer	ca 8000-8500		12-H-1169-47
Point	Paleo Indian	Dalton Cluster	Justice 35	8500-7900 BC		12-H-1169-48
Point	Paleo Indian	Dalton	Justice 40	8500-7900 BC		12-H-1169-49
Point	Paleo Indian	Dalton	Justice 40	8500-7900 BC	Burlington	12-H-1169-50
Point	unknown	unclassified	n/a	unknown		12-H-1169-51
Scraper	unknown			unknown		12-H-1169
Unclassified/broken	unknown			unknown		12-H-1169
Unclassified/broken	unknown			unknown		12-H-1169
Unclassified/broken	unknown			unknown		12-H-1169
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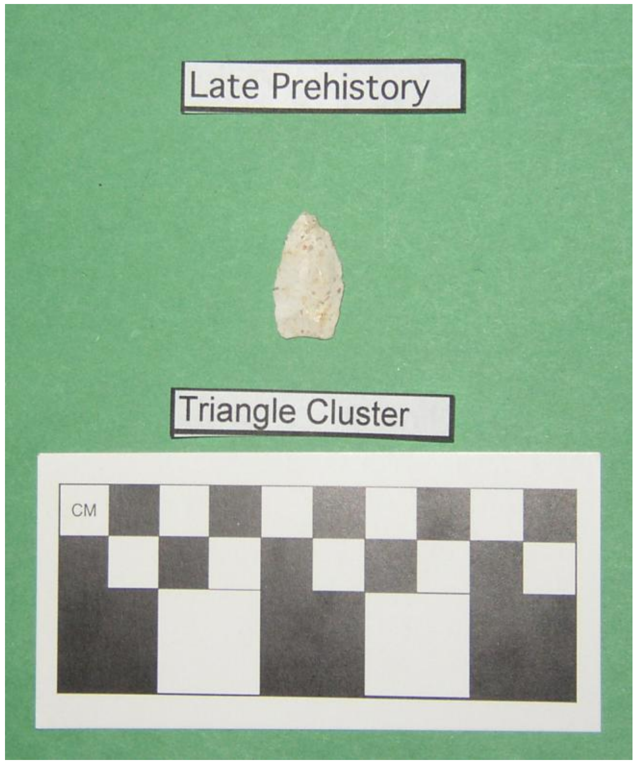
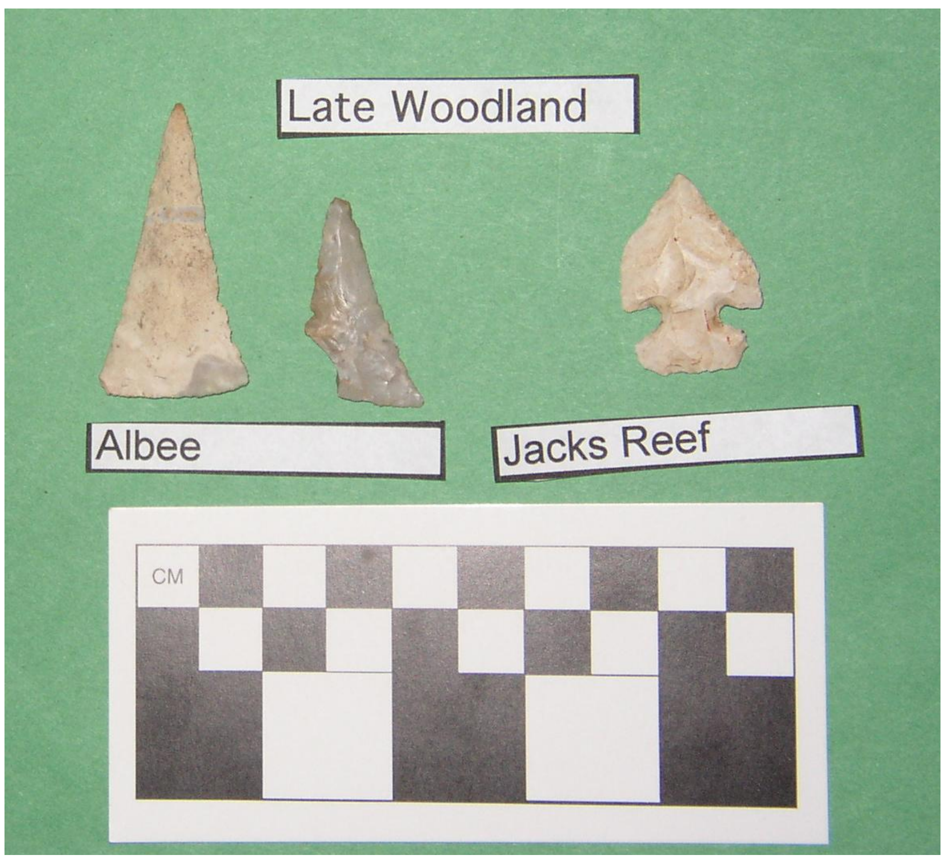

Late Prehistory
Triangle Cluster
CM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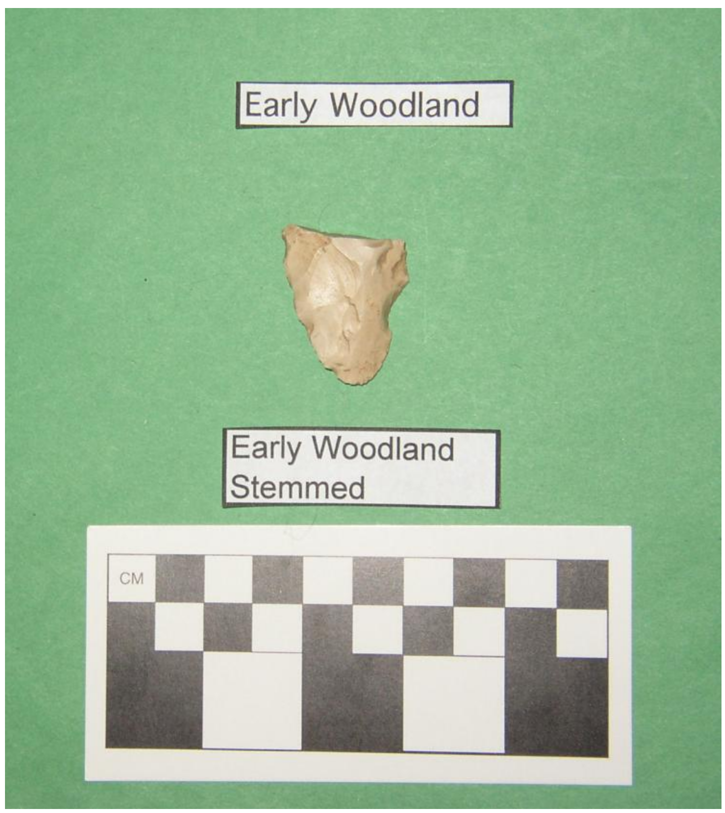
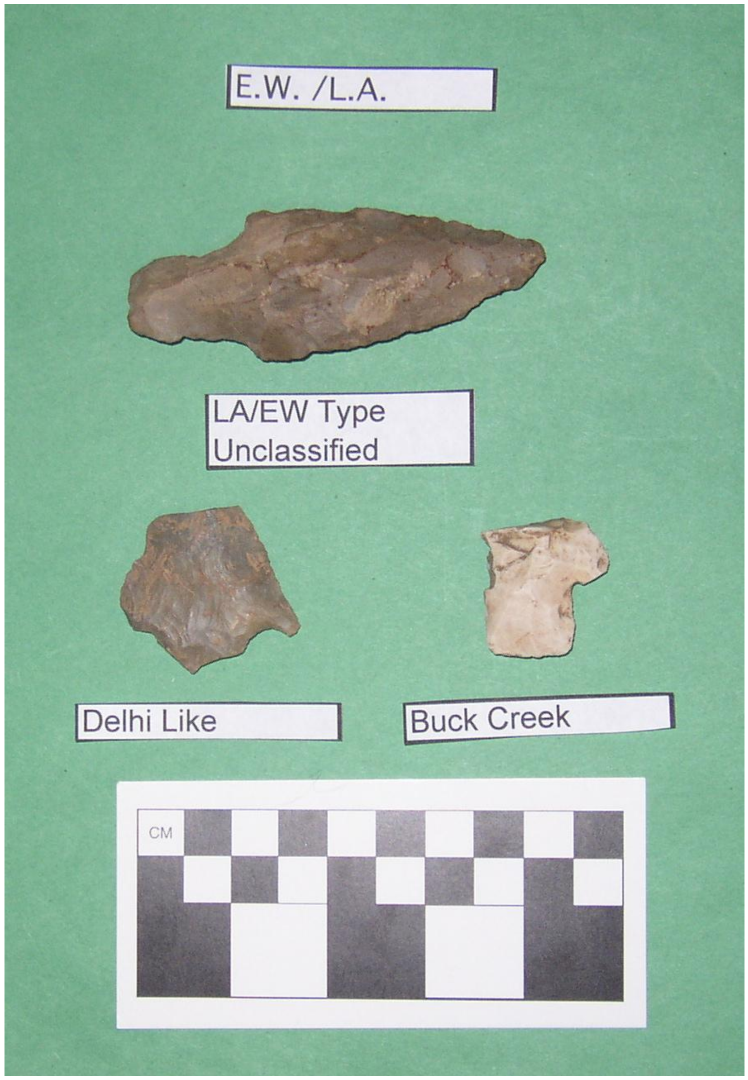
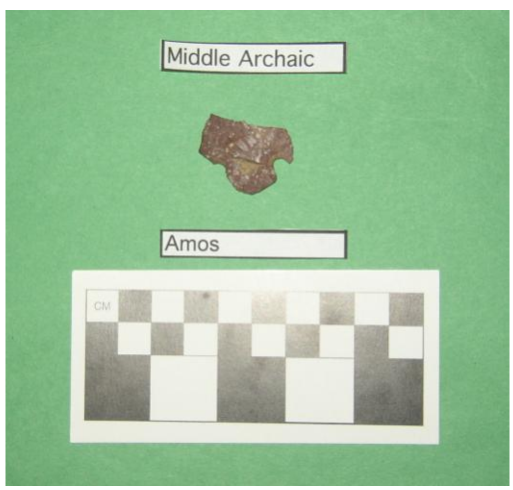
Albee
Jacks Reef
CM


Middle Woodland
Snyders
Robbins
CM


Early Woodland
Early Woodland
Stemmed
CM


E.W. /L.A.
LA/EW Type
Unclassified
Delhi Like
Buck Creek
CM

Late Archaic
Riverton
Saratoga Like
Riverton Preform
Merom Expanding Stem
Snook Kill Like
Lakoma
Brewerton
Table Rock Cluster
Matanzas Side Notched
CM
LA Stemmed

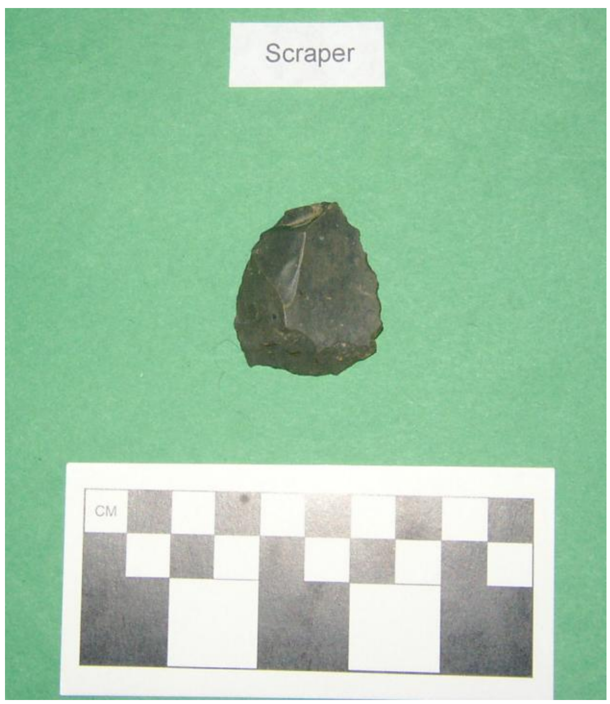


Middle Archaic
Amos
CM


Early Archaic
Kirk Stemmed
Kirk Corner
Notched
Graham Cave
Side Notched
Big Sandy
Thebes Cluster
CM


Paleo Indian
Agate Basin
Late PaleoIndian
Late PaleoIndian
Lancolet
Dalton Cluster
Dalton
CM


unclassified
CM


Scraper
CM


Nondiagnostic
CM


Biface
12-H-1169-104
CM


Modified Flakes
CM

APPENDIX B

The following form is the standard form used for recording the results of each soil test.

Date_________________________ Initials_________
Bag#_____________________________

Data
Table#_______________________

Results: Notes:
Line Length: ____

Time elapsed for line development: ________________________

Ring around sample? Yes No

Time elapsed when ring developed: _______________________

Rank:
1 None 2 Weak 3 Regular 4 Good 5 Strong